Shibles. M. R.
1935

An evaluation of three methods of teaching ninth grade algebra

BOSTON UNIVERSITY

SCHOOL OF EDUCATION

Thesis

AN EVALUATION OF THREE METHODS OF TEACHING NINTH-GRADE ALGEBRA

Submitted by

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In partial fulfillment of requirements for the degree of Master of Education

1935

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CHAPTER I

INTRODUCTION

The Objectives of the Study

Effective teaching of any subject is dependent, at least in a measure upon the use of effective methods. It is a common belief that the benefits which pupils derive from any course depends in part on the ability and personality of the teacher, in part on the attitudes and abilities of the pupils, but to a larger extent on the teaching methods.

Algebra is recognized as a traditional subject in our secondary schools. It is probably because of this factor that so few of our teachers of the subject have evidenced real interest to explore some of the newer concepts of educational methods. It is true that occasionally one finds teachers experimenting with new methods but for most of its teachers algebra remains still a traditional subject to be taught in a traditional manner.

With this group in mind, this experiment was conducted. It was felt that if it could be shown that one or more of the methods used could produce greater gains, other factors being equal, such information would be most valuable. The benefit of such a finding, if applied, would be vitally felt in the accomplishment of the pupil, in the

CHAPTER I

INTRODUCTION

The Objectives of the Study

enrichment of the teaching technique, and in the efficiency of the school.

This study gives a limited amount of objective evidence concerning the outcomes of three different methods employed by the same teacher of ninth-grade algebra. These methods are later fully described and for the purpose of brevity are mentioned in the study as: (1) the recitation, (2) the supervised, (3) the unit method of teaching.

Within the necessary limitations of this study such differences in outcomes as appear may be attributed to the differences in the teaching method used, since groups of pupils whose achievements, under different methods of teaching, were compared and equated on the basis of probable ability to do the work of the course, and were taught by the same teacher using the same text book.

The study has been planned also to give some evidence on the relative advantages of the three types of teaching or methods employed for pupils in the equated groups who were in the upper level of ability and for those who were in the lower level of ability.

It was felt that such evidence might show that certain of the methods of teaching would be more valuable for one or the other of these two levels in ability. Such findings as might result would be much more valuable than mere subjective knowledge about the types of teaching.

CHAPTER II

THE EXPERIMENTAL CONDITIONS OF THE STUDY

The Nature of the Problem

Controlled experiment. - In order to arrive at an accurate conclusion in measuring these three methods of teaching ninth-grade algebra it was necessary to follow the controlled experiment group idea. This was accomplished through a rotation technique procedure. Tiegs defines this manner of experimenting as consisting of "simply two or more procedures applied in rotation to the subject on which the study is to be made". 1/

Tiegs and Crawford in their book, "Statistics for Teachers", illustrate the rotation method as employed to determine the effect of comparing note taking and listening. The experiment shows the technique used generally under this kind of controlled study. 2/

But as definite background material for this study in controlled technique "The Experimental Comparison of the Relative Effectiveness of two Sequences in Supervised Study" by Harl Roy Douglass 3/ and "The Admin-

1/ Tiegs, Ernest W., Tests and Measurements for Teachers, pp. 204, Houghton-Mifflin Company, Boston, Massachusetts 1931.

2/ Tiegs, Ernest W., and Crawford, Claude C., Statistics for Teachers, pp. 142-144, Houghton-Mifflin Company, Boston, 1930.

3/ Douglass, Harl R., The Experimental Comparison of the Relative Effectiveness of two Sequences in Supervised Study, University of Oregon Publication, Eugene, Oregon, 1927.

istration and Supervision of Homogeneous Grouping" by Roy O. Billett [1] were used to excellent advantage. Both studies employ to a more effective means the controlled techniques of this study.

Technique of Study. - Three methods of teaching ninth-grade algebra were devised and criteria set up, time limit arranged, and tests given before and at the close of each period. For clarification and designating purposes the three methods have been termed as: (1) the recitation, (2) the supervised, and (3) the unit method of teaching.

Methods used. - The recitation method embodied those teaching principles commonly referred to as traditional. The class period was used in giving the assignment, having board work, reciting, testing, and checking papers. No attempt was made to motivate, supervise, socialize, or employ any of the newer methods of teaching. It was as near to the traditional "lesson-hearing" method as it was possible for the teacher to conduct the class.

The supervised plan consisted of what many authorities have described as the "divided period" technique. In this plan the class period was divided in half for the purpose of recitation, testing, motivating, and supervising advanced work. Authority for this scheme is

[1] Billett, Roy O., The Administration and Supervision of Homogeneous Grouping, pp. 44-60, Ohio State University Series, Number 4, 1932.

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abundant. Of this phase of supervised study "this fundamental principle must be kept in mind, that on the average at least one half of the time must be given over to some form of supervised study." 1/

The unit procedure involved the use of the so-called unit method of instruction. With the use of this technique, long-period assignment sheets or units had to be devised. These were based on the actual work of the text book since a departure from this scheme would have added an undesirable variable in measurement. The unit assignment sheets, as may be seen from an examination of one, 2/ consisted of a unit of work laid out on the basis of minimum and maximum requirements. It was advocated that the more versatile pupil work the maximum while the slower pupil might do the lesser number. "In each case the pupil pursued the teacher instead of the teacher pursuing the pupil, as is usual under the traditional plan." 3/

In was, therefore, the purpose of this study to measure, through achievement gains, the effectiveness of each of these methods. The results of which ought to establish better teaching, lessen wastage of valuable time, and prove an invaluable aid to those in whose charge rests the responsibilities of supervision of instruction.

Time Element. - Each of the mentioned techniques were in force for a period of ten weeks. Hence for the completed study a total of 30 weeks was necessary.

1/ Douglass, Harl Roy, Modern High School Teaching, pp. 114, Houghton-Mifflin Company, Boston, Massachusetts, 1926.
2/ See Appendix, pp. 67-68.
3/ Shreve, Francis, Supervised Study Plan of Teaching, pp. 85 112, Johnson Publishing Co., New York, 1927.

Outside of this period, the testing was accomplished. This required approximately four weeks time. Tests were given prior to the new work of the ten week period and at the close of that time. While each group was measured according to the three methods, it was not possible to teach each method at the same time hence the need for the rotation scheme.

The study began about three weeks after the opening of school and concluded at the close of school. The periods of class work were each forty-five minutes in length.

Construction of Comparable Experimental Groups

Matching pupils. - In order to arrive at satisfactory and stable deductions, the twenty pupils in each group were equated according to their intelligence quotient, the results of an algebra prognostic test, and on the basis of the average of their past four years' marks in arithmetic.

Chronological age of the pupils was not considered a major factor since in determining intelligence quotient such is employed but as a matter of fact the variation in age was a negligible factor.

It must be admitted that the average of the past four years' arithmetic marks is an open issue as to relia-

bility but when used with other tests teacher estimates are of value. In each pupil case these marks, and the average of them was the result of not one teacher alone but of four - hence the measurement in itself became more reliable. It could be easily shown from this study that these marks tabulated very well with the achievement made by the pupils in this study, however such was not a function of this thesis.

Eighty-one pupils, the total number of pupils, in the two classes used in this study, were given the "Terman Group Test of Mental Ability" and the "Orleans Algebra Prognosis Test". The average arithmetic marks for the past four years of all of these pupils were taken from the accumulative school record. Out of this total number, twenty cases were equated or matched as perfectly and as evenly as it was possible to do. The results of the individual standing on each test with the average arithmetic marks determined then the matching of one pupil with another in the opposite group.

Strictly speaking this was not absolutely possible in all cases as may be noted from the table following but where ever pupil was matched against another who had a lower intelligence quotient by a few points it was done with a case that had a higher prognostic result or arithmetic average or both. In each case a balance was attempted and approximately gained.

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To illustrate the above procedure attention is called to the following cases.

Pupil number one in Group 1, who has an intelligent quotient of 131, an algebra prognosis standing of 172, and an average of 1 in his past four years' marks in arithmetic, is equated with pupil number one in Group 2 whose intelligence quotient is 143, algebra prognosis standing is 159, and average arithmetic marks of the past four years is 1. 1/ This case shows the matching in its poorest comparison. It will be noted that the intelligence quotients vary in difference by 13 points and that the prognosis standings vary by 13 points but this variation occurred in the intelligence quotient favoring one and in the prognosis test favoring the other. The average arithmetic marks were identical. It will be seen by the illustrative case how the writer attempted to balance such equated cases.

Against that case of poorer matching, examine case number 16 in Group 1 with case number 16 in Group 2. Here it will be seen the two cases in each of the three points used for equating are identical. Case number sixteen in Group 1 has an intelligence quotient of 102, a standing of 90 on the algebra prognosis test, and past arithmetic averages of a four year period of 2. The same case in Group 2 has exactly the same figures. Such

1/ See Table 1 pp. 10.

condition is ideal and represents the best of the matching. 1/

A more average case is illustrated in pupil number five of Group I as matched with pupil number five of Group II. Pupil number five in Group I has an intelligence quotient of 124, as against an intelligence quotient of 127 of pupil number five in Group II, an algebra prognosis standing of 156 as against one of 151 of pupil number five in Group II. Both pupils have an average of 1 for their past four years' marks in arithmetic. Such matching varies very little and is for the most part satisfactory for equating purposes. 2/

Out of the eighty-one pupils first considered for matching purposes, forty were chosen, twenty in each group. A larger number was preferred in this study but it was impossible to evenly equate, or to come near evenly equating additional cases.

A further explanation of the tests themselves follows under a discussion of tests later in this study.

1/ See Table 1 pp. 10
2/ See Table 1 pp. 10

Table 1. - Standing of each pupil in the two equated groups according to intelligence quotients, algebra prognosis results, and the average of the past four years of arithmetic marks. [1]

Group I				Group II			
Pupil Number	Intelligence Quotient	Prognosis Algebra Test	Average Arithmetic Marks [2]	Pupil Number	Intelligence Quotient	Prognosis Algebra Test	Average Arithmetic Marks [2]
1	131	172	1	1	143	159	1
2	129	153	2	2	130	124	2
3	128	133	1	3	130	142	1
4	126	112	2	4	128	112	2
5.	124	156	1	5	127	151	1
6	120	151	1	6	117	166	1
7	120	159	3	7	122	159	3
8	117	90	2	8	120	98	2
9	114	155	2	9	115	148	1
10	113	133	2	10	113	151	3
11	109	131	1	11	108	152	2
12	106	132	1	12	102	137	1
13	104	166	2	13	103	122	1
14	104	74	2	14	103	74	2
15	103	128	2	15	105	128	2
16	102	90	2	16	102	90	2
17	103	66	2	17	97	78	2
18	100	122	2	18	100	119	1
19	102	87	1	19	100	85	2
20	101	59	3	20	100	59	3

[1] For individual tables of intelligence quotients, algebra prognosis standings, and arithmetic averages see Appendix pp.

[2] 1 corresponds to A, 2 to B, 3 to C, and 4 to D or failure

Table I. - Standing of each pupil in the two equated groups according to intelligence quotients, algebra prognosis results, and the average of the past four years of arithmetic marks.

Group I			Group II		
Number	Intelligence Quotient	Prognosis Algebra Test	Number	Intelligence Quotient	Prognosis Algebra Test
121	172	1	143	159	1
129	153	2	130	134	2
128	133	3	130	142	1
126	112	4	128	112	2
124	156	5	127	151	1
120	151	6	117	106	1
120	159	7	122	159	3
117	90	8	120	98	2
114	156	9	115	148	1
113	133	10	113	151	3
109	131	11	109	152	2
106	132	12	103	137	1
104	126	13	103	122	1
104	74	14	103	74	2
103	128	15	105	128	2
102	90	16	102	90	2
103	66	17	97	72	2
100	122	18	100	119	1
102	87	19	100	85	2
101	89	20	100	89	2

Securing Comparable Experimental Conditions

Variables. - Having matched the pupils, an effort was made to control other variables which might unduly influence the result.

In a study of this nature no concern occupies greater attention of the experimenter than this question of variables. It is necessary to isolate the variable whenever possible. As Douglass points out, "Those factors or influences likely to affect the experimental results must be either eliminated, kept constant, or subjected to measurement and allowed for". 1/

It must be admitted that there are factors that are impossible to control. This is probably true of every experiment dealing with the human element. Illustrative of an uncontrolled factor is the question of individual industry. There are others which will occur to the mind of the reader but so far as it was possible all variable factors were eradicated. A brief discussion of some follows.

Teacher variable eliminated. - At first in thinking out the procedure of the experiment, it was planned to use three different nin-th-grade algebra classes taught by two different teachers. This idea ofcourse introduced a teacher variable. It can be easily understood that these teachers in their ability and understanding of methods might

1/ Douglass, Harl Roy, The Experimental Comparison of the Relative Effectiveness of Two Sequences in Supervised Study, University of Oregon Publication, Eugene, Oregon, pp. 177.

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be better adapted to use one of the three procedures to a greater advantage than the other - not an unreasonable assumption at all. Hence such an idea was abandoned and in its place the idea of two classes taught by one teacher was substituted.

The question of pupil variability has already been discussed. 1/

Test variables. - Realizing the benefits of standardized tests and their reliability but at the same time knowing that they fail to measure sections of subject matter fully, that is - fail to measure, at times, materials taught over short periods of work, it was decided to use in addition informal objective tests devised by the experimenter which would very definitely measure each ten-week period of work. It is the feeling of the writer that these tests measured more satisfactorily the periods of work with less variability than did the standardized tests. This opinion is borneout by Dr. Billett's study in homogeneous and heterogeneous grouping where he used both standardized and objective tests. "Objective tests proved slightly more desirable than the standardized tests as measure of results". 2/

In making out these objective tests, it was not always possible to forecast the exact chapter at which the work would close for that period but in each group the manual accompanying the text, Betz' "Algebra for Today",

1/ See pp. 6-10.
2/ Billett, Roy O., The Administration and Supervision of Homogeneous Grouping, pp. 107, Ohio State University Series, Number 4, 1932.

was used to excellent advantage. 1/ In this manual the author listed lessons and topics that he had found from years of experience to be about the correct proportion for assignment for the average classes. These aided greatly in forecasting the assignments for the advanced ten week periods and served admirably in building unit-assignment sheets and objective tests.

In no case did the classes get beyond the material covered in the objective tests and in a few instances failed to cover the whole of the material but since this was true of both groups the relative measure was constant.

Variation in amount of subject matter covered by the two groups. - In this study one group did not advance more rapidly than the other in the matter of covering materials. Both groups were kept carefully to approximately the same section of the text. This eliminated all possibility of one group starting with a greater gain in achievement than the other. All material used in building the objective tests, units of assignment, and daily work came from the text book. The exception to this would be only in materials used in class discussion by the instructor and in this no difference was evidenced.

It has been argued by some that since the materials covered by each group and under different methods were not the same that here rested a variable. To clarify the point

1/ Betz, William, Algebra for Today, First Course, Teachers Manual, Ginn and Company, Boston, Massachusetts, 1929.

an examination of the plan as carried out is shown:

Table 2. - Teaching procedures shown in rotation during the experiment

Groups	First Ten-Week Period	Second Ten-Week Period	Third Ten-Week Period
	Method Used	Method Used	Method Used
I	Recitaion	Unit	Supervised
II	Supervised	Recitation	Unit

It is true that the materials differed somewhat, as ofcourse they must, as the class advanced but the relative distribution of oral work, numerical work, and written problem work was quite equal under all three periods of the experiment.

Actually there are three experiments being conducted, one for each ten-week period.

During the first ten-week period, we are measuring the relative merits of the recitation and supervised procedures with two equated groups. The statistics are computed on this basis in mean gains in terms of standard deviations. Then the second ten-week period in the equated groups, we are endeavoring through the study to determine the relative values of the unit and recitation methods. Again computations are made and results recorded. During the third ten-week period, the supervised method is measured in comparison to

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During the first ten-week period, we are measuring ...e relative merits of the recitation and supervised proce- ...re with two equated groups. The statistics are computed ...this basis in mean gains in terms of standard deviations. ...n the second ten-week period in the equated groups, we ...e endeavoring through the study to determine the relative ...lues of the unit and recitation methods. Again computations ...e made and results recorded. During the third ten-week ...iod, the supervised method is measured in comparison to

the unit method with the equated groups. The statistical treatment follows as in the preceding cases. Thus in each period we have an experimental unit in itself and each method is measured in comparison to the other method. Considering the study in this light, the variable of differing materials of subject matter is minor.

Further-more since the gain of each group for each ten-week period was reduced to a mean gain in terms of standard deviations, they are comparable.

A table following later in the study shows the data on each unit of experimentation.

Many similar rotation technique studies have been conducted successfully. 1/

Text book variable. - To overcome possible variability caused by different text books both classes were supplied at the beginning of the year with the same text, "Algebra for Today" by William Betz. 2/

Teaching method variable. - As to overlapping of teaching methods from one plan to another, all that can be said is that the writer and the instructor endeavored to maintain each method as far as possible in each allotted period for experimentation. The instructor was heartily interested in the study and his care and cooperation made possible as accurate a study as could be made under our conditions for experimentation. All members of the staff from

1/ Tiegs, Ernest W., Tests and Measurements for Teachers, pp. 207-208, Houghton-Mifflin Company, Boston, 1931.
2/ Betz, William, op. cit.

the supervisory official to the writer did every thing that could be done to make for reliability and accuracy. A further consideration of methods as employed for each plan and group will be found in a later discussion.

CHAPTER III

A DISCUSSION OF THE THREE METHODS USED IN THE EXPERIMENT

Setting up the Criteria for each Method

Criteria established for the recitation plan. - Under this plan of teaching, the instructor endeavored to maintain the traditional recitation scheme of conducting his class. The advance assignment was given at the beginning of the class period, papers of the previous assignment collected, questions asked of pupils, recitation, drill, and board work followed. Tests were frequently used. Little or no individual help was given other than through board work or recitation. The period was to all purposes and indications a recitation conducted under the traditional method of teaching algebra. It was lacking in motivation, supervision, socialization, and individual help.

Criteria for the supervised plan. - In the supervised plan or the divided period, the methods used consisted of a period divided in half, that is twenty-two minutes the first part of the period were devoted to the assignment and the day's work while the remaining twenty-two minutes were used for supervised study of the advanced assignment. It was an arbitrary division of time and was rather strictly adhered to in this study.

It must be conceded that for the divided period plan of supervised study our periods were too short in time [1] but this was entirely unavoidable since a change here would have necessitated a wholly new program for the school. It was felt that even with this defect the trend of relative gains, since all periods for all of the plans were the same, would be a fair consideration.

The principal points of interest to the reader of the first twenty-two minutes of the period are:

1. Motivation of assignment
2. Clarification of difficulties
3. Informal discussion of day's work
4. Recitation
5. Testing
6. Checking papers

The second half of the period was devoted to the supervision of the advanced assignment. This supervision consisted of the rendering of:

1. Individual aid
2. Observing work
3. Correcting errors
4. Testing
5. Explaining
6. Fostering group work
7. Aiding in developing better study habits

1/ Kilzer, Louis R., Supervised Study, pp. 107-108, Professional and Technical Press, New York, 1931.

In fact, Douglass describes supervised study in its broadest sense as including "the whole of the teacher's activities, assignments, explanations, discussions, testing and all". 1/ Kilzer states that it should be used "whenever the pupil needs encouragement, wise guidance, and assistance in his learning activities". 2/

Criteria established for the unit plan. - In attempting to get a thorough understanding of the unit plan in teaching it was necessary to survey the literature in this phase of educational work and later to establish, as best served our needs, the phases of the knowledge obtained for the criteria of the unit plan.

Surveying the material written on the unit method of teaching. - There is no better source of material for the designated purpose than that found in a national survey conducted by Dr. Billett entitled "Provisions for Individual Differences, Marking and Promotion". 3/

To comprehend the unit plan as conceived by many educators involves an understanding of some of the plans from which certain aspects of the unit procedure have been derived. These plans have been commonly referred to as (1) Morrison's plan, (2) the Dalton plan, (3) the Winnetka plan, (4) the contract method, (5) the project method,

1/ Douglass, Harl Roy, Modern Methods in High School Teaching, pp. 106, Houghton-Mifflin Company, Boston, 1926.

2/ Kilzer, Louis R., op. cit., pp. 3.

3/ Billett, Roy O., Provisions for Individual Differences, Marking and Promotion, Bulletin Number 17, 1932, Monograph Number 13.

(6) differentiated assignments, and various modifications of one or another of these.

Morrison in his plan advocated that the subject matter be allocated into certain types such as "the appreciation type, the science type, the language type, and the pure practice type." 1/ In teaching procedure, he advocated these five steps: (1) exploration, (2) presentation, (3) assimulation, (4) organization, (5) recitation. The exploration period was used in ascertaining the knowledge of pupils prior to their being taught. The presentation period was used in giving a preview of the unit "through direct, convincing oral presentation". 2/ This step is followed by the assimulation period where the class is organized into a study room. The better students may do supplementary work, make oral reports, or contribute in general to the group. Following this period comes the organization period where the material is organized into "a coherent and logical argument and not merely an exhibition of facts". 3/ Those who have mastered the unit during the recitation period present it to the group.

The whole plan calls for the setting up of guide sheets carrying references, supplementary work, and aids to the making of tests.

Differentiated assignments are used extensively. "The typical procedure in differentiating assignments is to give the slower pupils quantitatively less to do and

1/ Billett, Roy O., op. cit., pp. 240-241.
2/ Ibid., pp. 240-241.
3/ Ibid., pp. 240-241.

to give them work which is quantitatively less difficult in that it requires less intelligence. The process is reversed for the brighter pupils". 1/

The Dalton plan needs consideration in the background material for unit construction. This plan embodies four major steps: (1) the classroom became a laboratory or work shop, (2) the pupil was allowed freedom to work out his contract either by himself or in a group, (3) assignments were made in the forms of contracts and challenges with minimum, average, and maximum, (4) the teacher is present in the room to maintain favorable conditions of study, to enlarge upon the assignment, to stimulate, direct and supervise the work. "In each case the pupil pursues the teacher instead of the teacher pursuing the pupil, as is usual under the traditional plan". 2/

Of more definite concern in forming of the unit plan is the so called Winnetka plan. This plan has been fostered by Burk and Washburne. Its keynote is individualized instruction. It embodies prognostic and diagnostic testing. Work is laid out in units and as rapidly as a unit is covered, the mastery test is given. The pupil's work is given to him in the form of the "assignment booklet". This booklet contains: (1) a statement to the child of what he is to try to get from the text, (2) essential materials not given in the text, (3) separate sets of exercises for each objective, (4) sets of answers of all

1/ Billett, Roy O., op. cit., pp. 241-261 .
2/ Shreve, Francis, Supervised Study Plan of Teaching, pp. 86-87, Johnson Publishing Company, New York.

exercises for self correction.

In its larger phases the plan embodies socialized, self-expressive, and creative procedures. Correlation of subject work is evident, homogeneous grouping on the basis of social age is found, and each child is dealt with in an individual manner.

These plans are the major ones that have supplied the background for the unit method in teaching. They have been summarized briefly for the purpose of acquainting the author with the literature of the field and also the reader if need be. Having covered the literature, the experimenter next endeavored, in the light of his survey, to set up principles for the unit construction for the study.

Building the units. - In constructing the units, it was necessary to depart from the better plan of selecting with great care materials, references, and supplementary work from here and there and for the sake of reliability in measurement follow the text chapter by chapter. It is granted that such is not conducive to building superior units but since each of our groups and plans had to be kept together and cover like material there was no other alternative.

The fundamental parts of our units as used in this study are: (1) directions for study, (2) references, (3) supplementary work, (4) outline of minimum and maximum essentials, (5) tentative time schedule.

As to the time allotment no hard and fast rule was followed but a tentative schedule was set up for the purpose of guiding the pupil in his allowance of needed time. In most cases the pupil covered an assignment each period or day. In most cases little or no stimulation was essential. Students plunged forward with splendid zeal.

The teaching steps under unit procedure consisted of: (1) introduction of unit, (2) individual work periods, (3) periods of class discussion, (4) testing period.

The introductory step served primarily to give the pupil a preview of the unit and to arouse his interest. It also served as an opportunity to diagnose individual needs and to determine the pupils knowledge about the unit.

As to the methods that were employed in the introductory step this list notes them: (1) class discussion, (2) purpose and content of the unit clearly indicated by the instructor, (3) preview of the unit-assignment sheet, (4) assignment, (5) oral questioning.

In most cases one period rendered time enough for this part of the work. Later individuals needed points clarified but this was accomplished by calling the group together for a few moments at the beginning of the period

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or helping individuals.

The chief function of the work period lay in solving and completing the assigned unit. Methods used during individual work period: (1) questions raised by individuals were answered by the teacher, (2) teacher carefully observed pupils at work and pointed out errors to individuals, and at times to the whole group as the need demanded, (3) classroom became a work room, (4) teacher aided in improving study habits, (5) discussions were directed by the teacher at times, (6) pupils worked individually for the most part but were assisted by other pupils at times,(Little group work was done.)(7) teacher gave brief objective tests, (8) assignment sheets were checked by instructor and weakness noted to be clarified later with goups or individuals.

The time required for this period depended entirely upon the length, difficulty, and type of unit work to be accomplished. A general time was set by the instructor but was changed or modified as need arose. Such happened occasionally.

In the period for class discussion, the attempt was made to clear up all difficulties, review the entire unit of work, give any needed drill work, have the pupil participate in oral discussion and boardwork. The time devoted to this period was again a matter of judgment upon the part of the instructor. It depended upon the nature of

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The major significance of the objective tests was to determine how well each pupil had mastered the material in the unit. Occasionally these tests indicated the need for additional drill material or clarification of uncertain phases of the work. Such was promptly supplied.

In evaluating the unit assignment and its varied procedure, it must be admitted that it so far meets the need of supplying work for individual needs far superior to any other technique. It is the basis of remedial work for slow pupils and through its differentiated content renders ample material for the more versatile pupil.

The unit assignments, as used in this study, follow in the appendix of this paper. 1/ It will be noted that many of the directions and aids for solutions are to be found in the text book, "Algebra for Today" by Betz. 2/

Further comments on these three plans, the recitation, the supervision, and the unit method occur along with the deductions and conclusions of the study itself.

1/ See Appendix, pp. 67-68.
2/ Betz, William, op. cit.

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CHAPTER IV

A DESCRIPTION OF THE TESTS USED IN THE EXPERIMENT

Standardized Tests Used in this Study

The Orleans Algebra Prognosis Test. - The first test to be given was that of the Orleans Algebra Prognosis test. 1/ The test was made for the purpose of predicting a pupil's algebra success and was used in our study for that purpose in attempting to match pupils for the two experimental groups. The test is constructed in twelve parts, each part excepting the first and last have a lesson preceding the test. The pupil studies the lesson and then solves the test. The parts of the test are: (A) arithmetic, (1) substitution in monomials, (2) use of exponents, (3) measuring of exponents, (4) substitution in monomials with exponents, (5) substitution in binomials with exponents, (6) like and unlike terms, (7) representation of relations, (8) representation of expressions, (9) positive and negative numbers, (10) problems, (11) additional of like terms, (12) summary test. 2/

In experimenting with the test in two different schools, the authors found the coefficient of correlation between the prognosis test and achievement test to be .82 in one school and .71 in the other. Since, additional material has been added. It is considered that a correlation of .80 is high enough for the purpose of the test.

1/ Orleans, Joseph B. and Orleans, Jacob S., Orleans Algebra Prognosis Test, World Book Company, New York, 1928. See samples in Appendix.

2/ Ibid.

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In experimenting with the test in two different schools, the authors found the coefficient of correlation between the prognosis test and achievement test to be .82 in one school and .71 in the other. Since additional material has been added, it is considered that a correlation of .70 is high enough for the purpose of the test.

Using the prognosis test. - In this study the prognosis test was given in October after the pupils had had nearly six weeks of algebra. Hence the scores were higher than they would have been had they been given at the beginning of the school year or at the end of the eighth grade but for the purpose of using the results to pair pupils this factor made no partidular difference since the individual scores would be relative and since the test was given to both groups on the same date. The scores made in this test by the selected pupils may be seen in Table I on page 10.

The Intelligence Quotient Tests. - The Terman Group Test of Mental Ability was given to find the intelligence quotient. 1/ This was used in two forms, A and B. Each form contained 185 items. The pupil was given the highest score made in either test. By giving both tests the margin or error was reduced. The forms were given about ten days from each other. Each form consumes about an ordinary school period. Educational authorities consider Terman's test to be one of the better intelligence tests on the market. For the intelligence quotients obtained in this investigation as they were used to match pupils, see Table 1 on page 10.

Columbia Research Bureau Algebra Test. - To measure the achievement or gains of pupils in the study

1/ Terman, Lewis M., Group Test of Mental Ability, Grades 7-12, World Book Company, New York, 1920

the Columbia Research Bureau Algebra Test [1] was used. The test consists of a series of two forms each. Form 1A-1B is for use during the first half of the school year while Forms 2A-2B are to be used in the last part of the school year. Achievement could be measured by using either form alone as, Form 1A for the first part of the year and Form 2A for the second part, but in order to get a more accurate measure both forms were used in this experiment and the sum of the results recorded. Test 1A-1B contained two parts, one part had thirty-six examples typically of the mechanical kind, the second part had twelve problems which needed a knowledge of equation for solution. In test 2A-2B there were two parts, the first part consisted of twenty equations to be solved and the second part had twenty-five problems involving the use of various equations.

The reliability of the test. - The authors found the coefficient of reliability of the entire test 1A-1B to be .94 for one group of 115 students and .89 for another group of 147 students. The score on the test correlated with the teachers' marks to the extent of .68 and .72 for the same two groups. On Forms 2A-2B the reliability found by correlating the odd numbered items with the even numbered ones on two hundred cases was .847 for the whole test. This score when computed into reliability coefficients of correlations by the Spearman-Brown formula was .917.

1/ Orleans, JosephB. , Orleans, Jacob S., Wood, Ben, Columbia Research Bureau Algebra Test, World Book Company, New York, 1929

Tests 1A-1B take forty-five minutes each while tests 2A-2B take fifty minutes each. It will be seen that much time was consumed in testing.

Objective Tests Used

Objective tests A, B, C. - Three objective tests were made by the writer covering strictly the material included in the ten-week period of experimentation as best as could be determined. These tests contained various forms of the new type tests such as, true-false, best answer, problems and solutions. 1/ Each item came from the basal text used in the study and the answers from the accompanying answer book. In scoring these tests all questions, except problems, counted as a point. Problems, since their difficulty was considered to be twice that of other items, scored two. The total scores of each test varied a little but largely they remained much the same in difficulty. A forty-five minute class period was used as the testing time for each objective test. It is assumed by the writer that these objective tests measured the pupil gain better than did the standardized tests since they bore more directly upon the tested material.

Many standardized tests, expecially is used over short periods of testing, actually measure very few items taught. This is ofcourse in direct variance with objective tests especially constructed for those periods.

1/ See Appendix for samples.

Testing Periods

Date of testing. - Form 1A-1B of the Columbia Research Bureau Algebra Test and Objective Test A were given at the beginning of the first ten weeks of experimentation and again at the close of the period. Measurement of the gain or loss was estimated.

Form 2A-2B of the Columbia Research Bureau Algebra Test and Objective Test B were given before the experiment of the second ten-week period began and like the preceding tests given again at the close of that period. Measurement of the gain or loss was deducted.

The results of Form2A-2B at the end of the second ten week period were the initial scores for the beginning of the third ten-week period since the same test was used again. Objective Test C was given at the opening of this period and at the close Form 2A-2B and Objective Test C were given. As in all preceding tests the gains and losses were tabulated.

CHAPTER V

PRESENTATION AND INTERPRETATION OF TEST DATA

Data Obtained from the Tests

Recording data. - The records of each pupil taking the tests have been carefully recorded. An examination of the table following will reveal that opposite to each pupil whose name has been designated by numbers in each group, is the sum of the gains made from the first two forms of the first standardized test given at the beginning of the first ten-week period. It must be kept in mind that each of these standardized tests had two forms and both were given at the same time and a composite score recorded. This procedure was repeated with the same test at the close of the first ten-week period and the gains of these two were recorded. The informal objective test A was given at the beginning of the first ten-week period and again at the close. The gain was computed from the score made the first time and the score made the second time. Each of the two different groups were under different procedures.

Table 3. - Scores and gains made by individual pupils during the first ten-week period.

Group I - Recitation Method							Group II - Supervised Method						
Pupil Number	Columbia Research Bureau Algebra Test 1A-1B		Gain	Informal Objective Test A		Gain	Pupil Number	Columbia Research Bureau Algebra Test 1A-1B		Gain	Informal Objective Test A		Gain
	(1)	(2)		(1)	(2)			(1)	(2)		(1)	(2)	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	57	60	3	25	27	2	1	44	69	25	33	34	1
2	50	58	8	26	34	8	2	31	35	4	22	16	- 6 1/
3	43	56	13	23	25	2	3	39	64	25	21	25	4
4	32	36	4	20	21	1	4	43	57	14	22	29	7
5	37	70	33	17	21	4	5	46	78	32	29	30	1
6	54	71	17	28	36	8	6	47	77	30	25	28	3
7	38	62	24	31	32	1	7	33	59	26	36	35	- 1
8	27	43	16	18	27	9	8	32	45	13	28	34	6
9	44	56	12	23	22	-1	9	47	67	20	26	32	6
10	47	64	17	22	30	8	10	38	67	29	24	28	4
11	39	49	10	33	36	3	11	39	51	12	21	22	1
12	45	60	15	27	32	5	12	32	33	1	20	23	3
13	51	57	6	22	40	18	13	33	42	9	20	20	0
14	28	45	17	16	22	6	14	23	33	10	15	18	3
15	21	38	17	15	22	7	15	36	46	10	26	27	1
16	39	57	18	11	22	11	16	16	29	13	13	20	7
17	23	37	14	16	19	3	17	21	39	18	18	18	0
18	35	57	22	27	22	- 5	18	23	54	31	20	25	5
19	25	36	11	17	24	7	19	16	38	22	20	17	- 3
20	16	18	2	8	11	3	20	12	22	10	10	14	4

1/ - indicates a loss rather than a gain.

It is to be noted that the scores made by each pupil at the beginning of each ten-week period is much smaller on the whole than at the close. These same scores at the beginning of the period in the case of the objective tests are much lower and in a few cases very low but the reader need only keep in mind that these tests covered practically all new and untaught materials. A close examination of this data is revealing.

The procedure followed for the second ten-week period did not change from that of the first ten-week period. The only changes that did occur were in the tests. In this period the Columbia Research Bureau Algebra test 2A-2B and the informal objective test B were used.

In the third ten-week period of experimentation the same standarized test, Columbia Research Bureau Algebra test 2A-2B, was used at the beginning and the end. The initial score therefore is the same as the last score obtained by this test in the second ten-week period. The informal objective test C was given at the beginning and at the close of the ten- week period. As in the preceding experimental periods the gains were computed.

Tables 4 and 5 will be found on the following pages.

Table 4. - Scores and gains made by individual pupils during the second ten-week period.

Group I - Unit Method							Group II - Recitation Method						
Pupil Number	Columbia Research Bureau Algebra Test 2A-2B		Gain	Informal Objective Test B		Gain	Pupil Number	Columbia Research Bureau Algebra Test 2A-2B		Gain	Informal Objective Test B		Gain
	(1)	(2)		(1)	(2)			(1)	(2)		(1)	(2)	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	27	44	17	1	7	6	1	26	58	32	6	12	6
2	35	72	37	5	12	7	2	13	31	18	1	5	4
3	33	52	19	4	10	6	3	32	53	21	5	11	6
4	19	34	15	5	10	5	4	29	62	33	8	11	3
5	18	48	30	4	12	8	5	26	62	36	6	16	10
6	41	72	31	5	12	7	6	30	48	18	8	7	-1
7	32	55	23	6	11	5	7	17	37	20	10	14	4
8	15	39	24	3	8	5	8	23	27	4	4	9	5
9	20	37	17	2	9	7	9	34	59	25	5	13	8
10	28	41	13	5	11	6	10	27	40	13	12	10	-2
11	24	68	44	6	12	6	11	12	18	6	7	10	3
12	21	47	26	5	11	6	12	15	41	26	2	7	5
13	14	27	13	6	13	7	13	19	43	24	2	7	5
14	20	32	12	2	9	7	14	11	19	8	1	6	5
15	13	29	16	5	3	-2	15	18	42	24	4	8	4
16	16	44	28	6	11	5	16	14	27	13	3	10	7
17	10	50	40	4	6	2	17	16	25	9	3	6	3
18	26	40	14	3	4	1	18	14	34	20	5	11	6
19	16	45	29	4	8	4	19	18	36	18	4	8	4
20	8	19	11	3	4	1	20	12	18	6	2	3	1

Table 4. - Scores and gains made by individual pupils during the second ten-week period.

Table 5. - Scores and gins made by individual pupils during the third ten-week period.

Group I - Supervised Method							Group II - Unit Method						
Pupil Number	Columbia Research Bureau Algebra Test 2A-2B		Gain	Informal Objective Test C		Gain	Pupil Number	Columbia Research Bureau Algebra Test 2A-2B		Gain	Informal Objective Test C		Gain
	(1)	(2)		(1)	(2)			(1)	(2)		(1)	(2)	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	44	44	0	3	8	5	1	58	53	-5	4	8	4
2	72	78	6	3	9	6	2	31	24	-7	1	3	2
3	52	66	14	6	7	1	3	53	53	0	3	8	5
4	34	29	-5	2	14	12	4	62	72	10	4	8	4
5	48	48	0	4	11	7	5	62	72	10	5	12	7
6	72	73	1	2	11	9	6	48	43	-5	7	11	4
7	55	54	-1	6	14	8	7	37	44	7	3	7	4
8	39	38	-1	1	9	8	8	27	28	1	2	4	2
9	37	44	7	3	4	1	9	59	69	10	4	13	9
10	41	51	10	1	6	5	10	40	64	24	5	11	6
11	68	73	5	6	11	5	11	18	24	6	4	10	6
12	47	55	8	4	7	3	12	41	46	5	2	3	1
13	27	38	11	3	7	4	13	43	53	10	2	8	6
14	14	37	23	2	6	4	14	19	31	12	2	5	3
15	29	41	12	2	7	5	15	42	53	11	5	11	6
16	44	53	9	4	2	-2	16	27	29	2	5	13	8
17	50	44	-6	1	12	11	17	25	39	14	4	10	6
18	40	46	6	3	3	0	18	34	30	-4	2	9	7
19	45	46	1	2	7	5	19	36	38	2	4	8	4
20	19	26	7	1	6	5	20	18	17	-1	1	2	1

Statistical Treatment of Data

The mean gain. - In measuring the three different procedures in each of the ten-week periods, the method of gains is used. This measurement process involves the use of data previously recorded. The mean gain or average gain can be computed by one or two methods. 1/ By the first method the mean gains of the scores made the first time the test was given and again the second time the test was given, were computed. The difference of these mean gains may then be calculated by subtraction. With the second method the individual scores are subtracted and mean gain of the difference obtained. By using both of these methods, one has an excellent check on the correctness of the data. Both methods were used in this study. In computing the mean gain 2/ from each test as seen in the three preceding tables, M_1 designates the mean gain in raw scores for the second time the test was given and M_2 the first time the test was given. This procedure is used so that the gain may be noted. These scores cannot be added to get the total mean gain favoring one procedure or another. This point is clarified by Dr. Billett's discussion regarding the mean gain in his original doctor's dissertation. It points out that the mean

1/ Billett, Roy O., Original Doctor's Dissertation, The Administration and Supervision of Homogeneous Grouping, pp. 161.

2/ Tiegs Ernest W., and Crawford, Claude C., Statistics for Teachers, pp. 49-60, Houghton-Mifflin Company, 1930, Boston.
Otis, Arthur S., Statistical Method in Educational Measurement, pp. 6-11, World Book Company, New York, 1917.
Rugg, Harold O., Statistical Methods Applied to Education, pp. 114-126, Houghton-Mifflin Company, Boston, 1917.
Tiegs, Ernest W., Tests and Measurements for Teachers, pp. 224-226, Houghton-Mifflin Company, Boston, 1931.

Statistical Treatment of Data

The mean gain. - In measuring the three different procedures in each of the ten-week periods, the method of gains is used. This measurement process involves the use of data previously recorded. The mean gain or average gain can be computed by one or two methods. 1/ By the first method the mean gains of the scores made the first time the test was given and again the second time the test was given, were computed. The difference of these mean gains may then be calculated by subtraction. With the second method the individual scores are subtracted and mean gain of the difference obtained. By using both of these methods, one has an excellent check on the correctness of the data. Both methods were used in this study. In computing the mean gain 2/ from each test as seen in the three preceding tables, M_d designates the mean gain in raw scores for the second time the test was given and M_g the first time the test was given. This procedure is used so that the gain may be noted. These scores cannot be added to get the total mean gain favoring one procedure or another. This point is clarified by Dr. Millett's discussion regarding the mean gain in his original doctor's dissertation. It points out that the mean

1/ Millett, Roy O., Original Doctor's Dissertation, The Administration and Supervision of Homogeneous Grouping, p. 161.

2/ Tiegs Ernest W., and Crawford, Claude C., Statistics for Teachers, pp. 49-80, Houghton-Mifflin Company, 1930, Boston.

Otis, Arthur S., Statistical Method in Educational Measurement, pp. 6-11, World Book Company, New York, 1917.

Ruch, Harold O., Statistical Methods Applied to Education, pp. 114-150, Houghton-Mifflin Company, Boston, 1917.

Tiegs, Ernest W., Tests and Measurements for Teachers,

gain on certain tests might be very low while others might be high. "Yet from the standpoint of importance, or from the standpoint of difficulty to achieve, they may be of equal value, or indeed the greater may be of lesser value." 1/

It is for this reason that it has been necessary to divide these mean gains by some common unit so that they may be added to give the total effect of one procedure of one group to that of another.

The standard deviation. - That common unit is the standard deviation of the group score taken as a whole and figured for each standardized test and each objective test. For this purpose the following formula was used:

$$\sigma = \left[\sqrt{\frac{\Sigma fd^2}{N} - \left(\frac{\Sigma fd}{N}\right)^2}\right] \times \text{size of class interval}$$ 2/

The median. - The medians for each of the tests were found. While they do not bear directly upon this study they are consistent with the allied data and are reported in the Appendix of this work. In computing the medians on this test data the formula reported by Tiegs was used. 3/ As a check against errors in this work the medians were worked according to the technique employed by Douglass. 4/

1/ Billett, Roy O., op. cit., pp. 163.
2/ Tiegs, Ernest W., op. cit., pp. 230.
3/ Ibid., pp. 225.
4/ Douglass, Harl Roy, Modern High School Teaching, pp. 418-419, Houghton-Mifflin Company, Boston, 1926.

Table 6. - The means made on each test for Group I and Group II.

Types of teaching procedures	Groups	Means											
		First ten- week period				Second ten- week period				Third ten-week period			
		Columbia Research Bureau Algebra Test		Informal Objective Test		Columbia Research Bureau Algebra Test		Informal Objective Test		Columbia Research Bureau Algebra Test		Informal Objective Test	
		1	2	1	2	1	2	1	2	1	2	1	2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Recitation	I	38	51.5	21.2	26.2	x	x	x	x	x	x	x	x
	II	x	x	x	x	20.3	39	4.9	9.2	x	x	x	x
Supervised	I	x	x	x	x	x	x	x	x	43.8	49.2	2.95	8.05
	II	32.5	50.2	22.4	24.7	x	x	x	x	x	x	x	x
Unit	I	x	x	x	x	21.8	44.7	4.2	9.01	x	x	x	x
	II	x	x	x	x	x	x	x	x	39	44.1	3.45	822

Table 7. - The mean gains made on each test for Group I and Group II.

Types of teaching procedures	Groups	Mean Gains					
		First Ten-week period		Second ten-week period		Third ten-week period	
		Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objec- tive Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Recitation	I	13.5	5	x	x	x	x
	II	x	x	18.7	4.3	x	x
Supervised	I	x	x	x	x	5.35	5.1
	II	17.7	2.3	x	x	x	x
Unit	I	x	x	22.9	4.8	x	x
	II	x	x	x	x	5.1	4.7

Group II.

The mean gains having been calculated, it was next necessary to find the standard deviations of each of these same test scores. This was done by using the formula already referred to. 1/

Table 8. - The standard deviations of the pupils' scores in Group I and Group II.

Types of teaching procedures	Groups	Standard Deviations											
		First ten- week period				Second ten- week period				Third ten-week period			
		Columbia Research Bureau Algebra Test		Informal Objective Test		Columbia Research Bureau Algebra Test		Informal Objective Test		Columbia Research Bureau Algebra Test		Informal Objective Test	
		1	2	1	2	1	2	1	2	1	2	1	2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Recitation	I	11.4	12.9	22.	24.5	x	x	x	x	x	x	x	x
	II	x	x	x	x	6.6	15.6	.9	3.3	x	x	x	x
Supervised	I	x	x	x	x	x	x	x	x	15.	13.4	2.4	3.3
	II	10.4	16.2	6.	6.3	x	x	x	x	x	x	x	x
Unit	I	x	x	x	x	8.4	13.2	1.8	2.4	x	x	x	x
	II	x	x	x	x	x	x	x	x	13.5	16.2	.54	3.0

1/ See pp. 38.

Mean gains in terms of standard deviation. - Having calculated the mean gains and the standard deviations of each test, the mean gains in terms of the standard deviation for these tests was sought. The formula [1] for the procedure was $\frac{M_1 - M_2}{\sigma_T}$. $M_1 - M_2$ was the difference in the mean gains and M_1 in this work happened to be larger so all the values are positive. σ_T represented the standard deviation.

For this process the standard deviation for the following tests, Columbia Research Bureau Algebra test Form 1A-1B and Form 2A-2B and the informal objective tests A, B, and C, was computed for both groups. A total of all cases in both groups was used.

Table 9. - Standard deviations of the distributions of scores, made by all pupils participating in the study, on the standardized and informal objective examinations used to measure outcomes. [2]

Tests (1)	Standard Deviations (2)
Columbia Research Bureau Algebra Test 1A-1B	13.98
Columbia Research Bureau Algebra Test 2A-2B	7.6
Informal Objective Test A	6.6
Informal Objective Test B	2.56
Informal Objective Test C	1.92

1/ Billett, Roy O., The Administration and Supervision of Homogeneous Grouping, pp. 48-49, Ohio State University Studies, 1932.

2/ The score used to compute the standard deviations on the standardized tests were obtained by adding total score on Form 1 of the test to total score on Form 2.

The mean gain in terms of standard deviation is calculated for each test, standardized and objective, by first attaining the difference of the mean gains of the first time the test was given and of the second time the test was given and dividing this result by the standard deviation of the test. Example: Using Table 6 page 38 to get the mean gains of the tests and Table 8 page 39 to find the standard deviation, one has for the mean gain in terms of standard deviation:

$$\frac{51.5 - 38}{13.98} = .9656$$

This process is repeated for each of the tests. Table 10 shows the gains in terms of standard deviation for each form.

Table 10. - The mean gain of the tests in terms of standard deviations.

Types of teaching procedure	Groups	Mean Gains in terms of Standard Deviations					
		First ten-week period		Second ten-week period		Third ten-week period	
		Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Recitation	I	.9656	.7575	x	x	x	x
	II	x	x	2.460	1.679	x	x
Supervised	I	x	x	x	x	.7030	2.650
	II	1.859	.3484	x	x	x	x
Unit	I	x	x	3.019	1.875	x	x
	II	x	x	x	x	.6710	2.440

Using the standard deviation in this study. - The use of the standard deviation technique as employed in this experiment is briefly stated. The mean gain of each test is tabulated, then the standard deviation of those tests calculated. Then the mean gains in terms of the standard deviation, using the standard deviation derived by treating the total cases in the experiment, is derived by dividing this into the mean gain for the test. This gives the mean gains in terms of standard deviation for that particular test.

The second step is to compute the mean gains in terms of standard deviations between the means of the different groups using the same test with - in the same ten-week period. 1/ Once this technique is employed the means in terms of the standard deviations may then be added to determine a greater gain or loss by any of the procedures.

The mean gains in terms of standard deviations for each of these tests served as an excellent check in determining the mean gains in terms of standard deviations of two different procedures since the difference in the mean gain of the two procedures would equal the mean gain in terms of standard deviation or M_1 of one test minus M_2 of the other test. For example: The mean gain in terms of standard deviation of Columbia Research Bureau Algebra test 1A-1B is .9656 for the recitation method the first ten-week period with Group I; of 1A-1B for the same test in the supervised plan with Group II the mean gain in terms of standard deviations was 1.859.

1/ Like technique is used by Dr. Roy O. Billett in his doctor's dissertation, The Administration and Supervision of Homogeneous Grouping, original paper, pp 164-165.

The difference between these is .8941. When the mean gain in terms of standard deviation was computed using the mean gains for each group under different methods the answers checked. Thus, M_1 represents the mean gain of the supervised plan with Group I for the first ten-week period and M_2 the mean gain for the traditional with Group II for the same period. The standard deviation for the two groups of that same test was 13.98. Then $\frac{26 - 13.5}{13.98} = .8941$

In determining the difference in the mean gains in terms of standard deviations for the different procedures the same formula was used as before.

M_1 the mean gain in raw scores of the plan having the highest gain in each case and M_2 the mean gain in Raw scores of the plan of the lowest gain. This was true for both objective and standardized tests. The resulting quotients are each labelled according to the plan receiving the favoring score.

Table 11. - Difference of the mean gains in terms of standard deviation of the groups within each ten-week period.

Types of teaching procedures	Groups	First ten-week period		Second ten-week period		Third ten-week period	
		Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Recitation	I	— [1]	.409	x	x	x	x
	II	x	x	—	—	x	x
Supervised	I	x	x	x	x	.0328	.2083
	II	.8941	—	x	x	x	x
Unit	I	x	x	.559	.1935	x	x
	II	x	x	x	x	—	—

The figures in the preceding table reveal a difference favoring one or another of the three procedures involved in the study.

It was an endeavor of the experiment to show whether or not these figures are <u>real</u>, in that they actually favor one or another of the groups from the result of being equated and taught differently. [2] This can be accomplished through the application of the probable error formula. [3] Through the probable error formula only the maximum and minimum values can

1/ Measurement compared but the difference in gain favored the other equated group.

2/ Billett, Roy O., op. cit., pp. 165.

3/ Walker, Helen M., <u>The Standard Error of a Difference</u>, Journal of Educational Psychology, Volume XX, pp. 57-58.

Table 11. - Difference of the mean gains in terms of standard deviation of the groups within each ten-week period.

Type of test	Group	First ten-week period	Second ten-week period	Third ten-week period
		(1) (2)	(3) (4)	(5) (6)	(7) (8)
Speed-ing	I	Columbia Informal Reserach Objective	Columbia Informal Reserach Objective	Columbia Informal Reserach Objective
	II	Bureau tive Test	Bureau tive Test	Bureau tive Test
Procedure	I	Algebra Test	Algebra Test	Algebra Test
	II			
Interest	I	x x	x x	.409 [1] x	x x
	II	x x	x x	— —	x x
Number-ing	I	x x	x x	x x	.0328 .2083
	II	.8941 —	x x	x x	x x
Merit	I	x x	x x	.559 .1938	x x
	II	x x	x x	x x	— —

The figures in the preceding table reveal a difference favoring one or another of the three procedures involved in the study.

It was an endeavor of the experiment to show whether or not these figures are real, in that they actually favor one or another of the groups from the result of being equated and taught differently. [2] This can be accomplished through the application of the probable error formula. [3] Through the probable error formula only the maximum and minimum values can

[1] Measurement compared but the difference in gain favored the other equated group.

[2] Gillett, Hoy C., op. cit., pp. 165.

[3] Walker, Helen M., The Standard Error of a Difference, Journal of Educational Psychology, Volume XX, pp. 272-284.

be determinded. Because of the limited time for this study it was not possible to calculate the coefficient of correlation of the tests and since the minimum probable error formula uses this, it was impossible to consider it.

The formula used in this computation is known as the short formula for computing the probable error of the difference of two means in terms of standard deviations. It yields the maximum value which the probable error could have.1/

The maximum probable error formula is:

P. E. $_{M_1 - M_2} = \frac{.6745}{\sigma_T} \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}$

Once the probable error is found, it is possible to calculate the critical ratio. In this study the critical ratio was obtained by dividing the difference of the mean gains of the two plans in each period by the probable error. In using this formula the standard deviations of each test was used as σ_1 and σ_2. N_1 and N_2 represented the cases involved which in this instance was twenty each. σ_T is the standard deviation derived from using all forty cases employed in the study. 2/

1/ Walker, Helen M., op. cit.

2/ See Table 8.

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nstance was twenty each. σ_1^2 is the standard deviation derived
rom using all forty cases employed in the study. [2]

[1] Walker, Helen M., op. cit.
[2] See Table 8.

Table 12. - Probable error obtained from the differences in the mean gains of the groups in terms of standard deviations.

Types of teaching procedures	Groups	First ten-week period		Second ten-week period		Third ten-week period	
		Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Recitation	I	—— 1/	.1940	x	x	x	x
	II	x	x	——	——	x	x
Supervised	I	x	x	x	x	.3968	.0611
	II	.1600	——	x	x	x	x
Unit	I	x	x	.2112	.0373	x	x
	II	x	x	x	x	——	——

The critical ratio is a procedure used for the purpose of determining the probability of like results again occurring should the experiment be repeated. Table 13 shows tha number of chances out of a 1000 that certain critical ratios may be due to chance error. 2/

1/ Measurement compared but the difference in gain favored the other equated group.

2/ Billett, Roy O., op. cit., pp. 198.

Table 13. - Probable error obtained from the differences in the mean gains of the groups in terms of standard deviations.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Selection	I	——	.1940	x	x	x	x
	II	x	x	——	——	x	x
Number used	I	x	x	x	x	.3968	.0611
	II	.1600	——	x	x	x	x
Unit	I	x	x	.2112	.0373	x	x
	II	x	x	x	x	——	——

The critical ratio is a procedure used for the purpose of determining the probability of like results again occurring should the experiment be repeated. Table 13 above has a number of chances out of a 1000 that certain critical ratios may be due to chance error.[3]

Table 13. - Number of chances out of 1000 that a given critical ratio may be due to chance error or improper sampling.

Critical Ratio	Chances out of 100 that ratio indicated is due to chance error or improper sampling 1/
(1)	(2)
0.0	500
0.5	368
1.0	250
1.5	155
2.0	89
2.5	46
3.0	22
3.5	9
4.0	4
4.5	1

Thus, it will be noted that a critical ratio such as 3.4 for example, which was obtained on an informal objective test in this study, has but about 9 chances out of a 1000 of being a chance error. An examination of the table shows like figures for other critical ratios obtained.

Table 14, which follows, is for the difference in mean gains in terms of standard deviations as the tests of different procedures were used. The purpose was to throw light on the value of the different methods as they progressed in each ten-week period.

1/ Billett, Roy O., op. cit.

Table 13. - Number of chances out of 1000 that a given critical ratio may be due to chance error or improper sampling.

Critical Ratio (1)	Chances out of 100 that ratio indicated is due to chance error or improper sampling (2)
0.6	500
0.8	368
1.0	250
1.5	165
2.0	99
2.5	46
3.0	22
3.5	9
4.0	4
4.5	1

Thus, it will be noted that a critical ratio such as .4 for example, which was obtained on an informal objective set in this study, has but about 3 chances out of a 1000 of being a chance error. An examination of the table shows like figures for other critical ratios obtained.

Table 14, which follows, is for the difference in mean gains in terms of standard deviations as the tests of different procedures were used. The purpose was to throw light on the value of the different methods as they progressed in each ten-week period.

1/ Billett, Roy O., op. cit.

Table 14. - Critical ratio obtained from dividing the difference in mean gains in terms of standard deviations by the probable error.

Types of teaching procedures	Groups	First ten-week period		Second ten-week period		Third ten-week period	
		Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Recitation	I	---[1/]	2.108	x	x	x	x
	II	x	x	---	---	x	x
Supervised	I	x	x	x	x	.0806	3.400
	II	5.580	---	x	x	x	x
Unit	I	x	x	2.640	5.235	x	x
	II	x	x	x	x	---	---

1/ Measurement compared but the difference in gain favored the other equated group.

Table 14. - Critical ratio obtained from dividing the difference in mean gains in terms of standard deviations by the probable error.

Types of Test	Group	First ten-week period	Second ten-week period		Third ten-week period	
		Columbia Informal Test	Columbia Informal Test	Research Objective- Bureau of Algebra Test	Columbia Informal Test	Research Objective- Bureau of Algebra Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Selection	I	—— [1]	2.108	x	x	x
	II	x	x	——	x	x
Super-lead	I	x	x	x	.0306	3.400
	II	6.380	——	x	x	x
Unit	I	x	x	2.840	5.235	x
	II	x	x	x	——	——

[1] Measurement compared but the difference in gain favored the other equated group.

Outcomes of this study. - The findings of the study are interesting. Since each of the ten-week periods amounted to individual units of experiments, the deductions of these findings are to be first considerd. 1/ The data is that that has been derived from calculating the difference of the mean gains in terms of the standard deviation.

An examination of Graph 1 shows the trend in each of these periods. When the difference of the standardized tests and the informal objective test is considered, the difference of the mean gains favors the supervised plan by .4851 for the first ten-week period.

It is to be noted that during the second ten-week period the difference in mean gains in terms of the standard deviation for both standardized and informal objective test favors the unit plan. This total figue is .7525. In the third ten-week period when the difference in the mean gains in terms of standard deviation was computed between the supervised procedure and the unit, it was found that the difference favored the supervised plan by a total of .2411. It is evident therefore that the supervised plan taken as a whole shows greater gain but such a statement should only be considered in the light of the findings for each testing period.

1/ See Table 11, pp. 44.

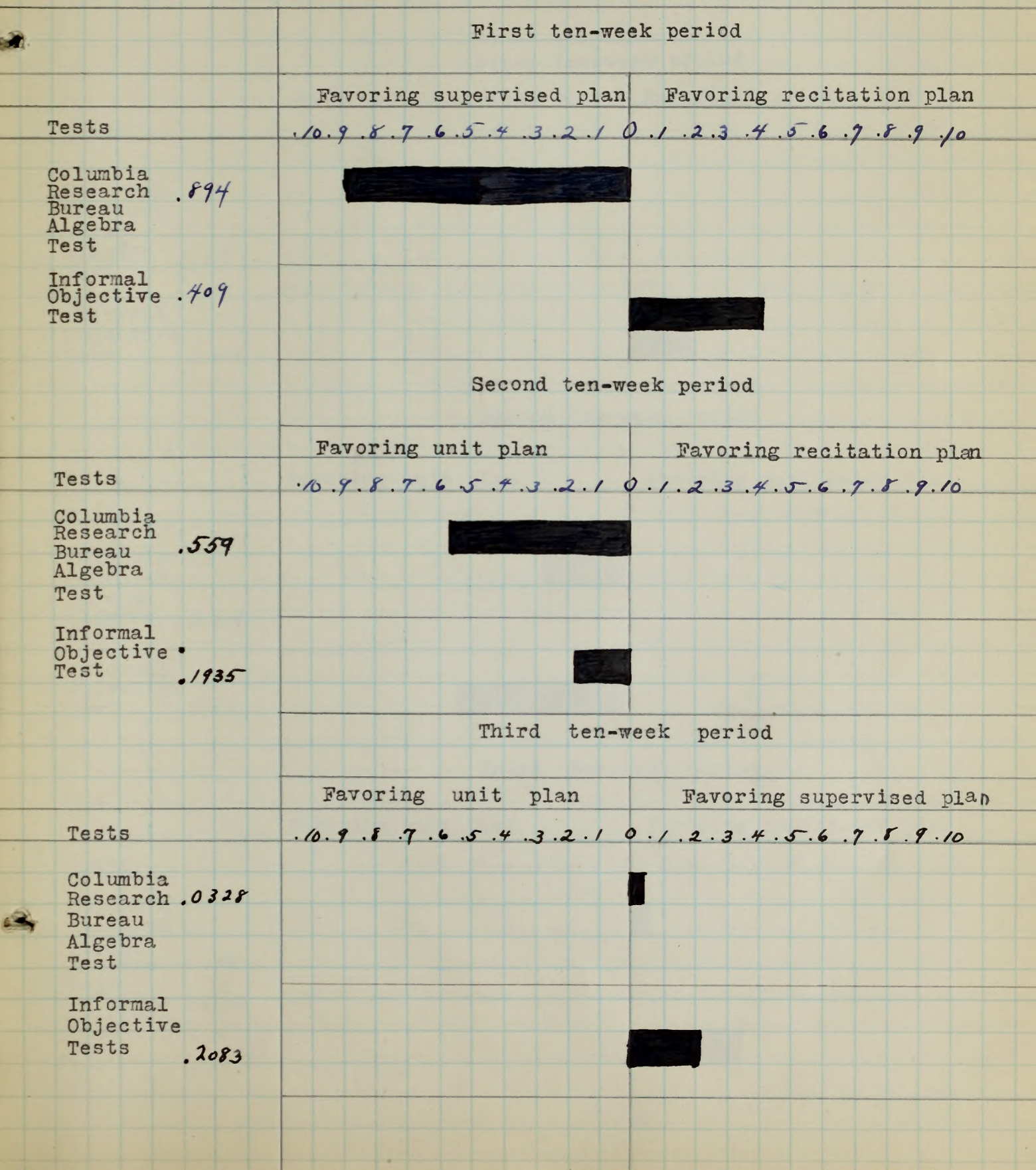
Outcomes of this study. - The findings of the study are interesting. Since each of the ten-week periods amounted to individual units of experiments, the deductions of these findings are to be first considered. [1] The data is that that has been derived from calculating the difference of the mean gains in terms of the standard deviation.

An examination of Graph I shows the trend in each of these periods. When the difference of the standardized tests and the informal objective test is considered, the difference of the mean gains favors the supervised plan by .4852 for the first ten-week period.

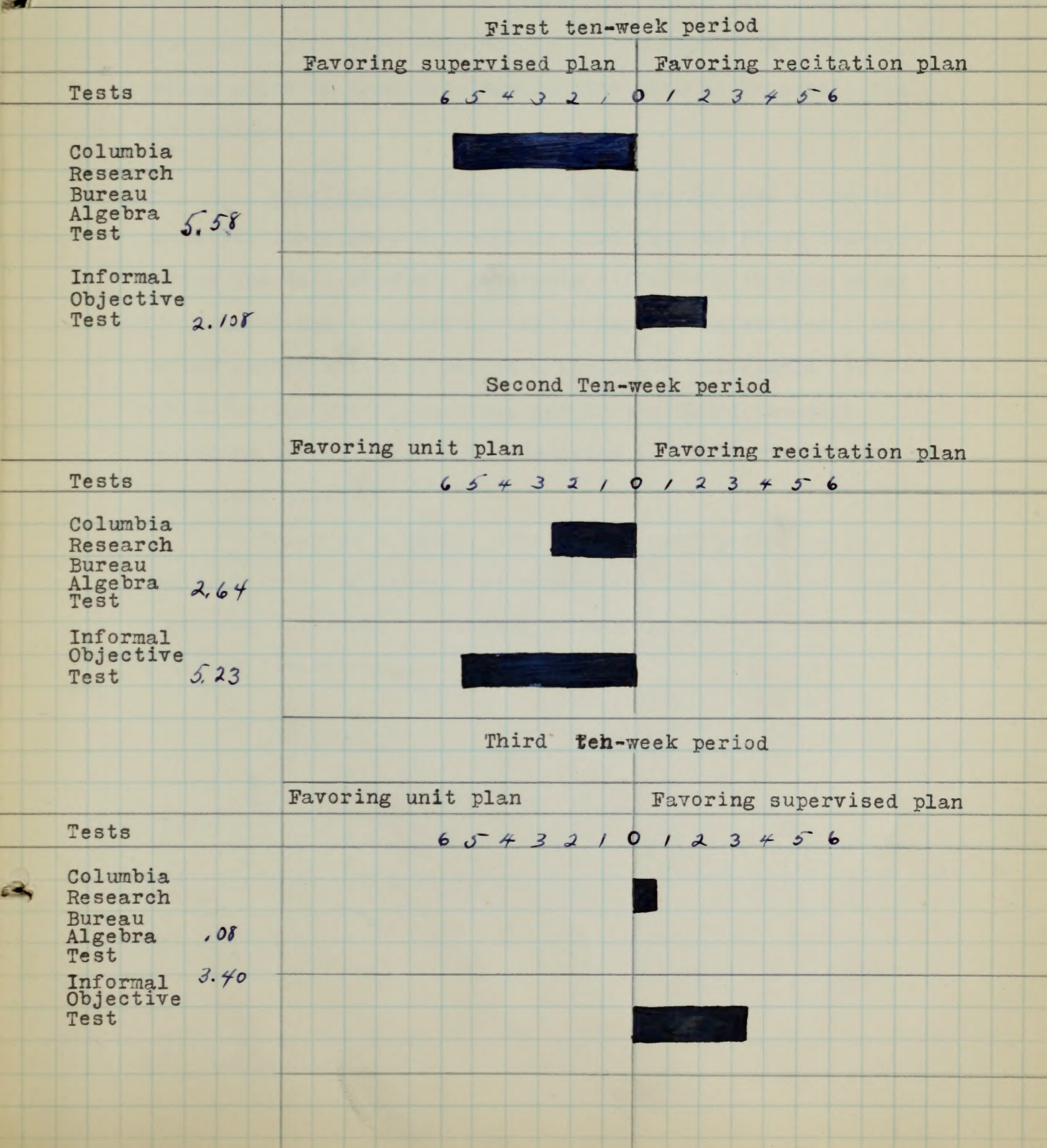
It is to be noted that during the second ten-week period the difference in mean gains in terms of the standard deviation for both standardized and informal objective test favors the unit plan. This total figure is .7858. In the third ten-week period when the difference in the mean gains in terms of standard deviation was computed between the supervised procedure and the unit, it was found that the difference favored the supervised plan by a total of .3411. It is evident therefore that the supervised plan taken as a whole shows greater gain but such a statement should only be considered in the light of the findings for each testing period.

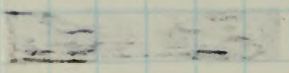
[1] See Table II, pp. 44.

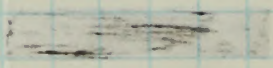
Graph 1. - Difference of mean gains in terms of standard deviation for each ten-week period.

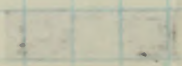


Graph 2. - Critical ratio obtained from dividing the differences of the mean gains in terms of the standard deviations by the probable error.









To be sure that our figures would likely run true if the experiment were repeated, these critical ratios are shown. The data for this is taken from Table 14. [1] These critical ratios when compared to the chances in a 1000 for chance error or improper sampling are seen to be creditable conclusions.

Conclusions drawn from the experiments. - It is possible, therefore, to conclude that for the first ten-week period the data showed a favorable difference in mean gains in terms of the standard deviation for the supervised plan, in the second ten-week period a favorable difference is noted for the unit procedure, and in the third ten-week procedure the difference in the gains is favorable to the supervised plan.

Taken as a whole, considering each period as individual units of study, the supervised plan seems to show a greater favorable difference in mean gains in terms of standard deviations.

1/ See pp. 47/

CHAPTER VI

COMPARISON OF THE UPPER HALF OF THE GROUPS AND OF THE LOWER HALF OF THE GROUPS.

Studying the Effects of the Teaching Procedures upon the Upper Half of the Groups and upon the Lower Half of the Groups.

The purpose of this part of the study. - Since pupils differ widely in ability and since methods and teaching techniques are necessary to meet this variation, an interesting part of this study was the objective to learn the effect of the three plans on the upper half of the pupils as compared to the lower half in each of the groups.

Division of groups. - The pupils were first divided evenly in Groups I and Group II on the basis of intelligence quotient. On the data sheets labelled Tables 3, 4, and 5 pages 32, 34, 35, one may find the scores and gains of each pupil on each test. The pupils designated by numbers 1-10 are the "upper half" of the group and those listed as numbers 11-20 are the "lower half" of the group.

Statistical treatment. - As in the preceding part of this paper the mean gains were used as methods of measurement. The data was treated with the same statistical technique. Table 16 shows the mean made in each test by Group I and for Group II for the "upper half" and the "lower half" of the pupils.

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Table 16. - The means of the test scores for both groups of the upper half and the lower half.

Types of teaching procedures	Groups	Means											
		First ten-week period				Second ten-week period				Third ten-week period			
		Columbia Research Bureau Algebra		Informal Objective Test		Columbia Research Bureau Algebra		Informal Objective Test		Columbia Research Bureau Algebra		Informal Objective Test	
		1	2	1	2	1	2	1	2	1	2	1	2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Recitation	I_u [1]	42.9	57.6	23.3	27.5	x	x	x	x	x	x	x	x
	I_l	32.2	45.4	19.2	25.0	x	x	x	x	x	x	x	x
	II_u	x	x	x	x	25.7	47.7	6.5	10.8	x	x	x	x
	II_l	x	x	x	x	14.9	30.3	3.3	7.6	x	x	x	x
Supervised	I_u	x	x	x	x	x	x	x	x	49.4	52.5	3.1	9.3
	I_l	X	X	x	x	x	x	x	x	38.3	45.9	2.8	6.8
	II_u	40.	61.8	26.6	29.1	x	x	x	x	x	x	x	x
	II_l	25.1	38.7	18.3	20.4	x	x	x	x	x	x	x	x
Unit	I_u	x	x	x	x	26.8	49.4	4.0	10.2	x	x	x	x
	I_l	x	x	x	x	16.8	40.1	4.4	8.1	x	x	x	x
	II_u	x	x	x	x	x	x	x	x	47.7	52.2	3.8	8.5
	II_l	x	x	x	x	x	x	x	x	30.3	36.0	3.1	7.9

1/ The Roman num eral represents the group in each case. The subscript uis used to designate "upper half" and l - "lower half" of the group.

Table 17. - The mean gains of the test scores for both groups of the upper half and the lower half.

Types of teaching procedure	Groups	Mean Gains 1/					
		First ten-week period		Second ten-week period		Third ten-week period	
		Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Recitation	I_u	14.7	4.2	x	x	x	x
	I_l	13.2	5.8	x	x	x	x
	II_u	x	x	22.0	4.3	x	x
	II_l	x	x	15.4	4.3	x	x
Supervised	I_u	x	x	x	x	3.1	6.2
	I_l	x	x	x	x	7.6	4.0
	II_u	21.8	2.5	x	x	x	x
	II_l	13.6	2.1	x	x	x	x
Unit	I_u	x	x	22.6	6.2	x	x
	I_l	x	x	23.3	3.7	x	x
	II_u	x	x	x	x	14.5	5.0
	II_l	x	x	x	x	5.7	4.8

Table 17. - The mean gains of the test scores for both groups of the upper half and the lower half.

		Mean Gains 1/					
		First ten-week period		Second ten-week period		Third ten-week period	
		Columbia Informal Reasoned Objective- tive Bureau Algebra Test	Bureau Objective- Algebra Test	Columbia Informal Reasoned Objective- tive Bureau Algebra Test	Bureau Objective- Algebra Test	Columbia Informal Reasoned Objective- tive Bureau Algebra Test	Bureau Objective- Algebra Test
	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	I_U	14.7	4.2	x	x	x	x
	I_L	13.2	5.8	x	x	x	x
	II_U	x	x	22.0	4.3	x	x
	II_L	x	x	15.4	4.3	x	x
	I_U	x	x	x	x	3.1	6.2
	I_L	x	x	x	x	7.6	4.0
	II_U	21.8	2.5	x	x	x	x
	II_L	13.6	2.1	x	x	x	x
	I_U	x	x	25.6	6.2	x	x
	I_L	x	x	23.3	3.7	x	x
	II_U	x	x	x	x	14.5	5.0
	II_L	x	x	x	x	5.7	4.8

It will be recalled that in order to be able to get the probable error for the results when the difference of the mean gains in terms of standard deviations was computed that it was necessary to have the standard deviation of the scores of each test. These were computed and are tabulated.

Table 18. - The standard deviation of pupils' scores in groups one and two for the upper half and the lower half.

Types of teaching procedure	Groups	Standard Deviations					
		First ten-week period		Second ten-week period		Third ten-week period	
		Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Recitation	I_u	8.97	3.27	x	x	x	x
	I_l	10.27	7.23	x	x	x	x
	II_u	x	x	6.06	3.21	x	x
	II_l	x	x	.732	2.01	x	x
Supervised	I_u	x	x	x	x	12.48	1.98
	I_l	x	x	x	x	12.36	2.27
	II_u	4.71	4.50	x	x	x	x
	II_l	9.24	4.05	x	x	x	x
Unit	I_u	x	x	6.66	1.37	x	x
	I_l	x	x	5.88	4.50	x	x
	II_u	x	x	x	x	11.94	3.90
	II_l	x	x	x	x	9.27	7.23

It will be recalled that in order to be able to
t the probable error for the results when the differences
the mean gains in terms of standard deviations was com-
ted that it was necessary to have the standard deviation
the scores of each test. These were computed and are
culated.

Table IX. - The standard deviation of pupils' scores in groups one and two for the upper half and the lower half.

Groups		Standard Deviations					
		First ten-week period		Second ten-week period		Third ten-week period	
		Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	I_U	8.97	3.27	x	x	x	x
	I_L	10.27	7.25	x	x	x	x
	II_U	x	x	6.06	3.21	x	x
	II_L	x	x	.782	2.01	x	x
	I_U	x	x	x	x	12.48	1.98
	I_L	x	x	x	x	12.56	2.27
	II_U	4.71	4.60	x	x	x	x
	II_L	9.24	4.05	x	x	x	x
	I_U	x	x	6.66	1.87	x	x
	I_L	x	x	5.88	4.50	x	x
	II_U	x	x	x	x	11.94	3.90
	II_L	x	x	x	x	9.27	7.25

Following the same technique as in the first part of this study, the mean gains in terms of standard deviations was calculated. 1/

Table 19. - The mean gains of the tests in terms of standard deviations for the upper half and for the lower half of each group.

Types of teaching procedure	Groups	Mean Gains in Terms of Standard Deviation					
		First ten-week period		Second ten-week period		Third ten-week period	
		Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Recitation	I_u	1.05	.637	x	x	x	x
	I_l	.944	.879	x	x	x	x
	II_u	x	x	2.89	1.68	x	x
	II_l	x	x	2.03	1.68	x	x
Supervised	I_u	x	x	x	x	.408	3.22
	I_l	x	x	x	x	1.00	2.08
	II_u	1.56	.379	x	x	x	x
	II_l	.973	.318	x	x	x	x
Unit	I_u	x	x	2.97	2.42	x	x
	I_l	x	x	3.065	1.45	x	x
	II_u	x	x	x	x	1.90	2.47
	II_l	x	x	x	x	.75	2.5

1/ See pp. 40-41.

Following the same technique as in the first part of this study, the mean gains in terms of standard deviations were calculated.

Table 19. - The mean gains of the tests in terms of standard deviations for the upper half and for the lower half of each group.

		Mean Gains in Terms of Standard Deviation					
		First ten-week period		Second ten-week period		Third ten-week period	
		Columbia Research Bureau Algebra Test		Columbia Research Bureau Algebra Test		Columbia Research Bureau Algebra Test	
		Objective Test	Informal Test	Objective Test	Informal Test	Objective Test	Informal Test
	(2)	(3)	(4)	(5)	(6)	(7)	(8)
I	I_u	1.05	.637	x	x	x	x
	I_l	.944	.879	x	x	x	x
II	II_u	x	x	2.89	1.68	x	x
	II_l	x	x	2.93	1.68	x	x
I	I_u	x	x	x	x	.408	3.22
	I_l	x	x	x	x	1.00	2.08
II	II_u	1.58	.379	x	x	x	x
	II_l	.973	.318	x	x	x	x
I	I_u	x	x	2.97	2.42	x	x
	I_l	x	x	3.065	1.46	x	x
II	II_u	x	x	x	x	1.90	2.47
	II_l	x	x	x	x	.78	2.8

See pp. 40-41.

Following the calculation of the mean gains in terms of standard deviations of each of the tests, the next consideration was that of getting the difference of the mean gains in terms of standard deviations of the upper half and of the lower half of each group. This difference would show a gain for one of the procedures in each case.

Table 19. - Difference of the mean gains in terms of standard deviations of the groups within each ten-week period.

Types of teaching procedure	Groups	First ten-week period		Second ten-week period		Third ten-week period	
		Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Recitation	I_u	---[1]	.2545	x	x	x	x
	I_l	---[1]	.5606	x	x	x	x
	II_u	x	x	---	---	x	x
	II_l	x	x	---	.2343	x	x
Supervised	I_u	x	x	x	x	---	.7812
	I_l	x	x	x	x	.250	---
	II_u	.5078	---	x	x	x	x
	II_l	.03	---	x	x	x	x
Unit	I_u	x	x	.08	.7421	x	x
	I_l	x	x	1.04	---	x	x
	II_u	x	x	x	x	1.50	---
	II_l	x	x	x	x	---	.4115

1/ Indicates that this test was used in getting the difference of the mean gains in terms of standard deviation but that the difference favored the other plan which in this case was the supervised plan.

Following the calculation of the mean gains in terms of standard deviations of each of the tests, the next consideration was that of getting the difference of the mean gains in terms of standard deviations of the upper half and the lower half of each group. This difference would show again for one of the procedures in each case.

Table 19. - Difference of the mean gains in terms of standard deviations of the groups within each ten-week period.

Group	First ten-week period		Second ten-week period		Third ten-week period	
	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test
	(3)	(4)	(5)	(6)	(7)	(8)
I_U	——	.2545	x	x	x	x
I_L	——	.5606	x	x	x	x
II_U	x	x	——	——	x	x
II_L	x	x	——	.2343	x	x
I_U	x	x	x	x	——	.7812
I_L	x	x	x	x	.250	——
II_U	.5078	——	x	x	x	x
II_L	.03	——	x	x	x	x
I_U	x	.08	.7421	x	x	
I_L	x	1.04	——	x	x	
II_U	x	x	x	x	1.80	
II_L	x	x	x	——	——	.4218

Table 20. - Probable error obtained from the differences in the mean gains of the groups in terms of standard deviations.

Types of teaching procedure	Groups	First ten-week period		Second ten-week period		Third ten-week period	
		Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Recitation	I_u	---	.0283	x	x	x	x
	I_l	---	.8453	x	x	x	x
	II_u	x	x	---	---	x	x
	II_l	x	x	---	1.29	x	x
Supervised	I_u	x	x	x	x	4.82	.485
	I_l	x	x	x	x		---
	II_u	.1542	---	x	x	x	x
	II_l	.6627	---	x	x	x	x
Unit	I_u	x	x	2.84	3.09	x	x
	I_l	x	x	1.63	---	x	x
	II_u	x	x	x	x	4.84	---
	II_l	x	x	x	x	---	.840

This data on the probable error was used in computing the critical ratio as explained previously. 1/

1/ See pp. 47.

Table 20. - Probable error obtained from the differences in the mean gains of the groups in terms of standard deviations.

Group	First ten-week period	Second ten-week period		Third ten-week period	
	Columbia Informal Research Objective Test	Columbia Informal Research Objective Test	Research Objective Test	Research Objective Test	Research Objective Test
	(2)	(4)	(5)	(6)	(7)	(8)
I_U		.0885	x	x	x	x
I_J		.8453	x	x	x	x
II_U	x	x			x	x
II_J	x	x		1.29	x	x
I_U	x	x	x	x		.435
I_J	x	x	x	x	.852	
II_U		.1542		x	x	x
II_J		.6627		x	x	x
I_U	x	x	2.84	3.09	x	x
I_J	x	x	1.65		x	x
II_U	x	x	x	x	.840	
II_J	x	x	x	x		.540

1/ This data on the probable error was used in computing critical ratio as explained previously.

Table 21. - Critical ratio obtained from dividing the difference of the mean gains in terms of standard deviations by the probable error. 1/

Types of teaching procedure	Groups	First ten-week period		Second ten-week period		Third ten-week period	
		Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test	Columbia Research Bureau Algebra Test	Informal Objective Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Recitation	I_u	---	8.99	x	x	x	x
	I_l	---	.663	x	x	x	x
	II_u	x	x	---	---	x	x
	II_l	x	x	---	.1810	x	x
Supervised	I_u	x	x	x	x	---	1.61
	I_l	x	x	x	x	.520	---
	II_u	3.29	---	x	x	x	x
	II_l	.044	---	x	x	x	x
Unit	I_u	x	x	.0278	.0403	x	x
	I_l	x	x	.636	---	x	x
	II_u	x	x	x	x	.310	---
	II_l	x	x	x	x	---	.490

1/ See discussion pp. 46.

Table 21. - Critical ratio obtained from dividing the difference of the mean gains in terms of standard deviations by the probable error. 1/

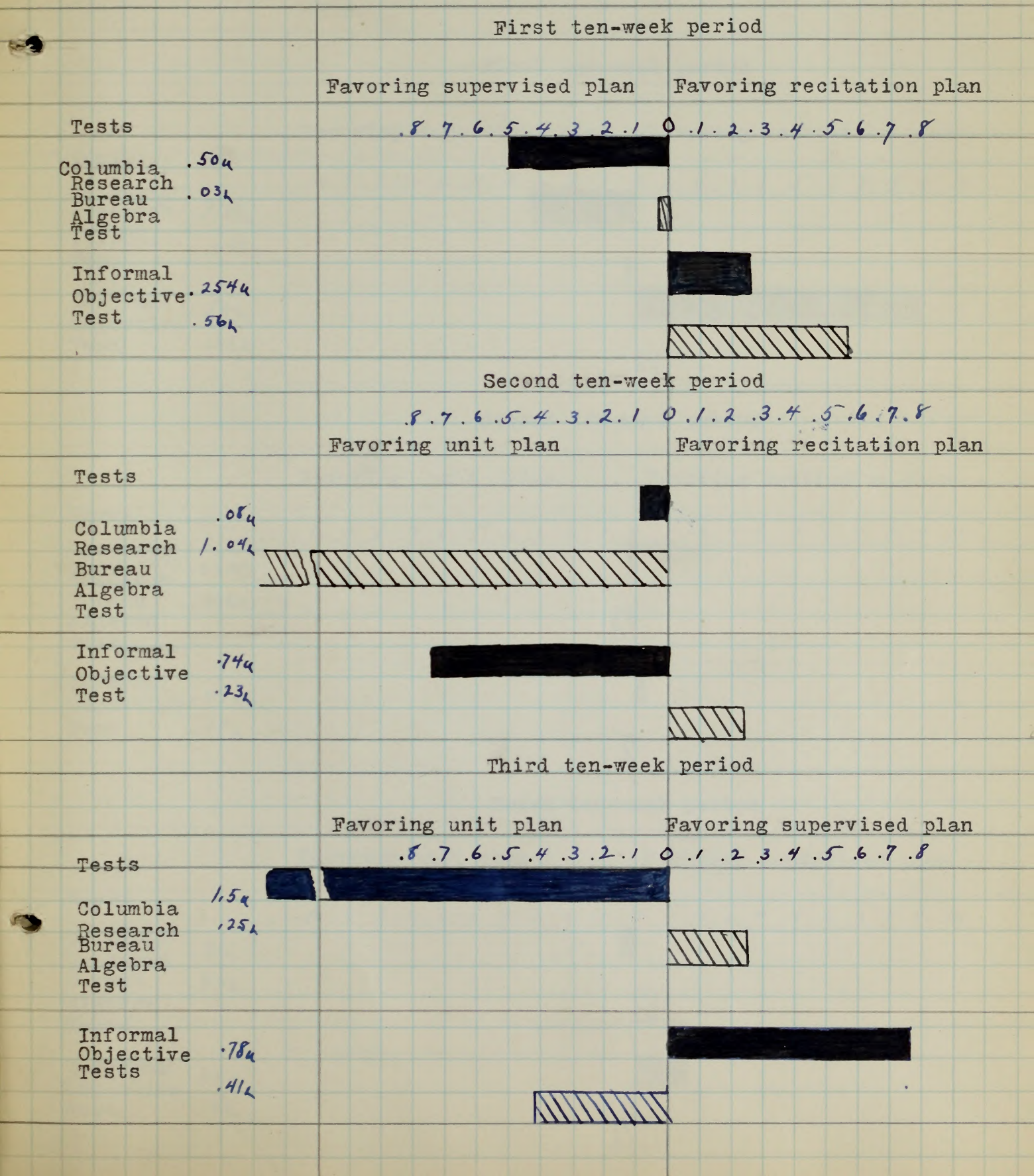
(1)	(2)	(3) Pilot period: Algebra Test	(4) Pilot period: Ten-week Test	(5) Second ten-week period: Columbia Interest Research Objective Test	(6) Second ten-week period: Bureau Objective Test	(7) Third ten-week period: Columbia Interest Research Objective Test	(8) Third ten-week period: Bureau Objective Test
	I_U	----	8.93	x	x	x	x
	I_J	----	.663	x	x	x	x
	II_U	x	x	----	----	x	x
	II_J	x	x	----	.1810	x	x
	I_U	x	x	x	x	----	1.61
	I_J	x	x	x	x	.520	----
	II_U	3.29	----	x	x	x	x
	II_J	.044	----	x	x	x	x
	I_U	x	x	.0278	.0403	x	x
	I_J	x	x	.636	----	x	x
	II_U	x	x	x	x	.810	----
	II_J	x	x	x	x	----	.480

Outcomes of the study. - During the first ten-week period the difference of the mean gains in terms of standard deviation of the upper half equated pupils of Group I and Group II show a favorable difference in gain of .2533 1/ for the supervised procedure. In the second ten-week period the difference was favorable to the unit plan of teaching by .821. For the upper half pupils in the third ten-week period a difference of .72 was noted for the unit plan. So then as far as the upper half of the pupils in the equated groups were concerned the difference in the mean gains of the test in terms of standard deviation was favorable to the unit procedure of teaching by a considerable margin.

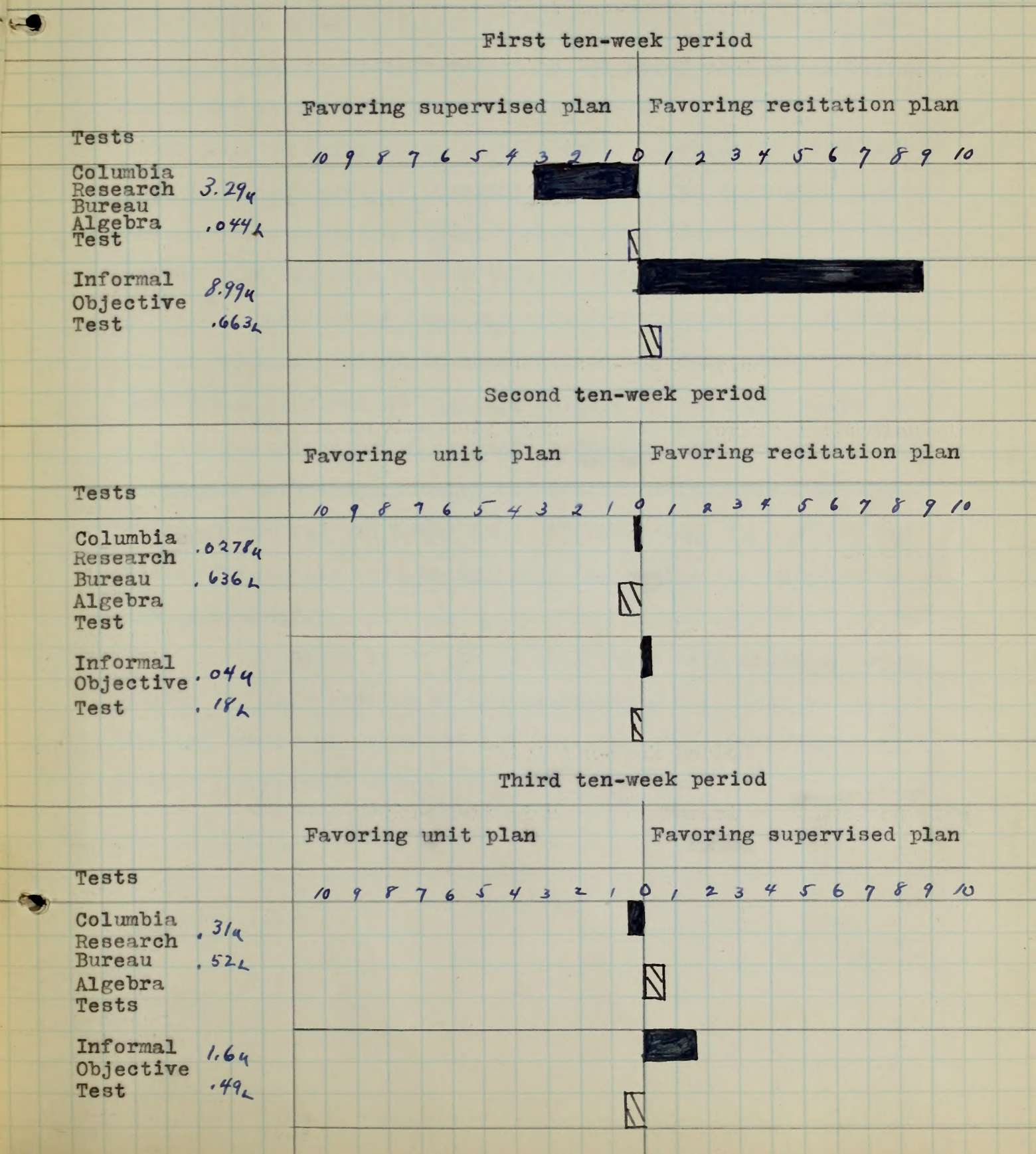
As to the lower half during the first ten-week period the difference of the mean gains in terms of standard deviation show .531 in favor of the recitation technique. In the second ten-week period this difference is favorable to the unit plan by .805. While the third ten-week period has a favorable difference of .16 for the unit plan.

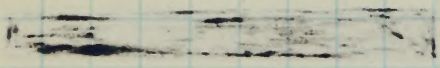
1/ This difference is obtained by getting the difference of the findings of the standardized and informal objective tests since their measurement is varied.

Graph 3. - The difference os mean gains in terms of standard deviations for each ten-week period for the upper half and the lower half of each group.



Graph 4. - The critical ratio obtained by dividing the difference of the mean gains in terms of the standard deviation by the probable error.





From an examination of the Table of critical ratios it will be noted that the differences in mean gains in terms of standard deviations have a lower total critical ratio computation for the unit procedure in the upper half group and hence the chances for the same measurement if repeated are less. This is interesting since a total computation of the mean gains in terms of standard deviation for the upper half favors the supervised plan but when the difference is considered for each ten-week period this is decreased.

Considering this upper half group then for the whole of the testing periods in the light of the difference of the mean gains in terms of standard deviations the favor seems to lay in the direction of the unit procedure with the supervised technique following closely, the latter having more favorable critical ratios. The lower half of the group by a much less margin favors the unit method with the recitation method following closely.

It needs to be stated that these measurements, especially for this section of the experiment, are based on a very limited mumber of cases and are therefore less reliable as to predictive value.

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It needs to be stated that these measurements, espe-
y for this section of the experiment, are based on a very
ed number of cases and are therefore less reliable as to
ctive value.

SUMMARY OF THE EXPERIMENT.

The experiment has certain shortcomings that cannot be overlooked. The experience of the writer in dealing with such an undertaking is a limiting factor in itself since he was necessarily learning through experience the techniques of such a study.

The small number of pupils tested and in each equated group makes for less reliability in the measurement, particularly is that true in the case of the upper half and the lower half of the groups.

With these groups there was not a wide range of intelligence quotients and hence the difference between them is small. A heterogeneous group or one with a greater range would have proved more valuable. This part of the study is open for further investigation. As it was the upper half of the groups in differences of mean gains in terms of standard deviations showed a favorable trend to the unit method. While the lower half of the groups showed a slight trend that way with the recitation method closely following.

With the whole group the difference of the mean gains in terms of standard deviations favored the supervised procedures and such a result when considered in the manner in which our plans were used is a reasonable outcome. It is most interesting to note that the unit proce-

SUMMARY OF THE EXPERIMENT.

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e he was necessarily learning through experience the
niques of such a study.

The small number of pupils tested and in each
ted group makes for less reliability in the measurement.
ticularly is that true in the case of the upper half
the lower half of the groups.

With these groups there was not a wide range of
lligence quotients and hence the difference between
n is small. A heterogeneous group or one with a greater
ge would have proved more valuable. This part of the
dy is open for further investigation. As it was the
er half of the groups in difference of mean gains in
ns of standard deviations showed a favorable trend to
unit method. While the lower half of the groups showed
light trend that way with the recitation method closely
lowing.

With the whole group the difference of the mean
ns in terms of standard deviations favored the super-
ed procedures and such a result when considered in the
ner in which our plans were used is a reasonable out-
e. It is most interesting to note that the unit proce-

dure follows and that the recitation method is last in comparison.

The study to those involved in the experiment has clearly indicated the great possibilities of the supervised procedure and the unit method in teaching of ninth-grade algebra in comparison to the recitation procedure.

The study is left open for further experimentation and investigation.

APPENDIX

Computation of the medians. - Those interested in the medians of the sum of these tests may study Table 22. These medians were computed according to the Tiegs method. 1/ As a check agains error they were also computed according to the method advocated by Douglass. 2/

Table 22. - A composite table showing the medians for each test in both groups.

Types of teaching procedure	Groups	Medians											
		First ten-week period				Second ten-week period				Third ten-week period			
		Columbia Research Bureau Algebra		Informal Objective Test		Columbia Research Bureau Algebra		Informal Objective Test		Columbia Research Bureau Algebra		Informal Objective Test	
		1	2	1	2	1	2	1	2	1	2	1	2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Recitation	I	39	57	21.5	24	x	x	x	x	x	x	x	x
	II	x	x	x	x	18.5	39	5.1	9.8	x	x	x	x
Supervised	I	x	x	x	x	x	x	x	x	45	46.5	3.3	8.6
	II	34	48.5	21.5	24.5	x	x	x	x	x	x	x	x
Unit	I	x	x	x	x	21	44	4.1	10.2	x	x	x	x
	II	x	x	x	x	x	x	x	x	39	44	4.0	9.5

1/ Tiegs, Ernest W., Tests and Measurements for Teachers, pp. 224-227, Houghton-Mifflin Company, Boston, 1931.

2/ Douglass, Harl Roy, Modern Methods in High School Teaching, pp. 418-419, Houghton-Mifflin Company, Boston, 1926

Table 23. - A composite table showing the medians for each test in the upper half and the lower half of each group.

Types of teaching procedures	Groups	Medians											
		First ten-week period				Second ten-week period				Third ten-week period			
		Columbia Research Bureau Algebra Test		Informal Objective Test		Columbia Research Bureau Algebra Test		Informal Objective Test		Columbia Research Bureau Algebra Test		Informal Objective Test	
		1	2	1	2	1	2	1	2	1	2	1	2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Recitation	I_u	43.5	60	24	28.5	x	x	x	x	x	x	x	x
	I_l	34	59	17	21	x	x	x	x	x	x	x	x
	II_u	x	x	x	x	27	51	6.7	11.5	x	x	x	x
	II_l	x	x	x	x	15.5	30	3.0	8.0	x	x	x	x
Supervised	I_u	x	x	x	x	x	x	x	x	46	50	3.7	9.2
	I_l	x	x	x	x	x	x	x	x	41	45	3	7.5
	II_u	40	65	26	30.2	x	x	x	x	x	x	x	x
	II_l	23	38.5	19.6	21	x	x	x	x	x	x	x	x
Unit	I_u	x	x	x	x	28.5	46	4.8	10.8	x	x	x	x
	I_l	x	x	x	x	16	43	5	9	x	x	x	x
	II_u	x	x	x	x	x	x	x	x	51	52.5	4.6	8.3
	II_l	x	x	x	x	x	x	x	x	33	35	3	9.2

A sample.

UNIT I

Equations of the First Degree in one Unknown.

Assignment I Ref. Betz - Algebra for Today

1. Read carefully pp. 233-235
2. Study each illustrative example on pp.235
3. Maximum requirement - Solve examples 1-28 pp. 236
4. Minimum requirement - Solve examples 1-20 pp. 236

Assignment II Ref. Betz - Algebra for Today

1. Study the illustrative form on pp. 237
2. Maximum requirement - Do problems 1-25 pp. 237-238
3. Minimum requirement - Do problems 1, 3, 5, 7, 9, and 11-25 inclusive pp. 237-238

Assignment III Ref. Betz - Algebra for Today

1. The illustrative example on pp. 239 is important for study
2. Maximum requirement - Solve examples 1-10 and the odd numbers from 11-33 pp. 239-240
3. Minimum requirement - Solve the odd numbers from 1-33 pp. 239-240

Assignment IV Ref. Betz - Algebra for Today

1. The paragraph number 121 and the illustrative forms on pp. 240-241 must be studied with great care in order to solve the next assignment
2. Maximum requirement - examples 1-29 pp. 242-243
3. Minimum requirement - examples 1-25 pp. 242-243

Assignment V Ref. Betz - Algebra for Today

1. Read paragraph 122 with care. Study the illustrative forms 1 and 2 on pp 244
2. Maximum requirement - Do problems 1-32 pp. 244-245
3. Minimum requirement - Do problems 1-27 pp. 244

A sample.

UNIT I

Equations of the First Degree in one Unknown.

Assignment I Ref. Beta - Algebra for Today

1. Read carefully pp. 233-235
2. Study each illustrative example on pp.235
3. Maximum requirement - Solve examples 1-28 pp. 236
4. Minimum requirement - Solve examples 1-20 pp. 236

Assignment II Ref. Beta - Algebra for Today

1. Study the illustrative form on pp. 237
2. Maximum requirement - Do problems 1-25 pp. 237-238
3. Minimum requirement - Do problems 1, 3, 5, 7, 9, and 11-25 inclusive pp. 237-238

Assignment III Ref. Beta - Algebra for Today

1. The illustrative example on pp. 239 is important for study
2. Maximum requirement - Solve examples 1-10 and the odd numbers from 11-33 pp. 239-240
3. Minimum requirement - Solve the odd numbers from 1-33 pp. 239-240

Assignment IV Ref. Beta - Algebra for Today

1. The paragraph number 121 and the illustrative forms on pp. 240-241 must be studied with great care in order to solve the next assignment
2. Maximum requirement - examples 1-29 pp. 242-243
3. Minimum requirement - examples 1-25 pp. 242-243

Assignment V Ref. Beta - Algebra for Today

1. Read paragraph 122 with care. Study the illustrative forms 1 and 3 on pp 244
2. Maximum requirement - Do problems 1-32 pp. 244-245
3. Minimum requirement - Do problems 1-27 pp. 244

Assignment VI ref. Betz - Algebra for Today

1. Same requirement for all - Solve problems 33-45 pp. 245

Assignment VII Ref. Betz - Algebra for Today

Percentage Problems
1. Maximum requirement - examples 1-17 pp. 246-248
2. Minimum requirement - examples 1-12 pp. 246-248

Assignment VIII Ref. Betz - Algebra for Today

Motion Problems
1. Guide your work by the illustrative procedure on pp. 248-249
2. Maximum requirement - problems 1-15 pp. 250-251
3. Minimum requirement - problems 1-12 pp. 250-251

Assignment IX Ref. Betz - Algebra for Today

Mixture Problems
1. Follow the illustrative example on pp. 252
2. Maximum requirement - Solve examples 1-14 pp. 252-254
3. Minimum requirement - Solve examples 1,3, 6, 7, 10, 14 pp. 252-254

Assignment X Ref. Betz - Algebra for Today

1. Maximum requirement - problems 1-24 pp. 254-256
2. Minimum requirement - problems 1-20 pp. 254-256

Assignment XI Ref. Betz - Algebra for Today

1. Review this whole unit of work with care. Ask questions about any problems or procedures that you are not sure of.

Assignment XII Ref. Betz - Algebra for Today

1. Test on unit

Assignment VI Ref. Beta - Algebra for Today

1. Have requirement for all - Solve problems 33-45 pp. 248

Assignment VII Ref. Beta - Algebra for Today

Percentage Problems
1. Maximum requirement - examples 1-17 pp. 246-248
2. Minimum requirement - examples 1-12 pp. 246-248

Assignment VIII Ref. Beta - Algebra for Today

Motion Problems
1. Guide your work by the illustrative procedure on pp. 248-249
2. Maximum requirement - problems 1-15 pp. 250-251
3. Minimum requirement - problems 1-12 pp. 250-251

Assignment IX Ref. Beta - Algebra for Today

Mixture Problems
1. Follow the illustrative example on pp. 252
2. Maximum requirement - Solve examples 1-14 pp. 252-254
3. Minimum requirement - Solve examples 1,3, 6, 7, 10, 14 pp. 252-254

Assignment X Ref. Beta - Algebra for Today

1. Maximum requirement - problems 1-24 pp. 254-256
2. Minimum requirement - problems 1-20 pp. 254-256

Assignment XI Ref. Beta - Algebra for Today

1. Review this whole unit of work with care. Ask questions about any problems or procedures that you are not sure of.

Assignment XII Ref. Beta - Algebra for Today

1. Test on unit

A sample.

OBJECTIVE TEST C

Name ..... Date .....

School ..... Teacher .....

Part I

Fractional Equations

Solve each equation. Write the answer after the same number as the example on the dotted line on the right side of the paper.

1. $\frac{n}{2} - \frac{n}{3} = 5$ 1. .....

2. $\frac{r+5}{2} - \frac{2r-5}{8} = \frac{2r}{3}$ 2. .....

3. $\frac{r-8}{2r} - \frac{r+8}{r} = \frac{3}{4}$ 3. .....

4. $\frac{n+1}{d} = \frac{1}{2}$ 4. .....

5. $\frac{x}{b} + \frac{x}{a} = a+b$ Find x 5. .....

6. $\frac{x}{4d} + \frac{x}{d} = 1$ Find x 6. .....

7. Solve the formula: $T = W + \frac{Wa}{G}$ for a 7. .....

8. Simplify: 8. .....

$$\frac{\frac{a+b}{a-b}}{\frac{a-b}{a+b}}$$

9. $3x + 1 + \frac{2}{x}$ 9. .....

10. $\frac{a-b}{x} + \frac{x^2y}{a}$ 10. .....

OBJECTIVE TEST C

Name ..... Date ....

School ..... Teacher .....

Part II

Solve each problem. Use the backside of this sheet for your work. Write the answer in the space at the end of the problem.

1. If an airplane consumed 40 gals of gas in going 370 miles, how much gas will be consumed in a trip of 3200 miles? (proportion)

1. .....

2. If a clerk earns $40 a week, show that his income (i) varies directly as the number of weeks (w) he works. If w = 10, find i. If i = $280, find w. (variation)

2. .....

3. Suppose that y varies inversely as x and that when x = 20, y = 5. Find y, when x = 50. (inverse variation)

3. .....

4. Find the missing number (x) in each of the following proportions:

a) $\frac{5}{7} = \frac{6}{x}$ b) $6x : 4c = 3r ; 5s$

4. .....

5. The annual premium on a $2500 life insurance policy was $70. At the same rate, what would be the premium on a policy for $6000? (solve by proportion)

5. .....

OBJECTIVE TEST C

Name ..... Date .....

School ..... Teacher .....

Part III

Square Root and Radicals

Draw a circle around the correct answer:

1. $5\sqrt{3} + 2\sqrt{3} = 7\sqrt{6}$, $14\sqrt{3}$, $7\sqrt{3}$ 1. .....

2. $3\sqrt{2} + \sqrt{8} = 12$, $6\sqrt{2}$, $\sqrt{48}$ 2. .....

3. $2\sqrt{3} + \sqrt{27} = 2\sqrt{30}$, $\sqrt{33}$, $5\sqrt{3}$ 3. .....

4. $20 - \sqrt{\frac{1}{5}} = \frac{9}{5}\sqrt{5}$, $10\sqrt{5}$, $\frac{1}{5}\sqrt{5}$ 4. .....

5. $2\sqrt{3} = 9$ $x = 4$ $x = 6\frac{3}{4}$ $x = 28$ 5. .....

Part IV

Equations of the Second Degree

Solve. Write the answers in the answer column on the right side of the paper.

1. $5x^2 = 100$ 1. .....

2. $3x^2 - 13x = 10$ 2. .....

3. $x^2 + 12x + 36 = 49$ 3. .....

4. $2x^2 + 5x - 12 = 0$ 4. .....

5. $4x^2 - 8nx + n^2 = 0$ 5. .....

OBJECTIVE TEST C

Name ..... Date .....

Teacher ..... Period .....

Part III

Square Root and Radicals

Circle around the correct answer:

1. $5\sqrt{3} + 2\sqrt{3} = 7\sqrt{6}$, $14\sqrt{3}$, $7\sqrt{3}$ .....

2. $3\sqrt{2} + \sqrt{8} = 12$, $6\sqrt{2}$, $4\sqrt{8}$ .....

3. $2\sqrt{3} + \sqrt{27} = 2\sqrt{30}$, $\sqrt{33}$, $5\sqrt{3}$ .....

4. $20 - \frac{1}{5}\sqrt{\frac{9}{5}} = 5$, $10\sqrt{5}$, $\frac{8}{5}\sqrt{5}$ .....

5. $\sqrt{3} \cdot 9 \times 4 \times 6\frac{2}{3} \times = 28$ .....

Part IV

Equations of the Second Degree

Write the answers in the answer column on the right of the paper.

1. $5x^2 = 100$ .....

2. $3x^2 - 13x = 10$ .....

3. $x^2 - 12x + 36 = 49$ .....

4. $2x^2 - 5x - 12 = 0$ .....

5. $4x^2 - 8nx + n^2 = 0$ .....

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